DEVELOPMENT OF A DESIGN METHOD FOR GLASS WINDOWS SUBJECTED TO BLAST LOADINGS

A Research Paper
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DANIEL T. MAGRO
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Submitted to the Department of Civil Engineering
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Table of Contents

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Abstract

The purpose of this research is to develop a method which can be used to predict the dynamic response of rectangular glass plates subjected to uniform blast loadings of varying durations. A computer code developed using an equivalent mass and force approach is presented. The results generated using this code are compared to results obtained from a detailed finite element solution and actual test data. The results of this comparison verify that the developed computer code provides a reasonable design tool.

List of Tables

List of Figures

List of Symbols

A - Area of the Window Plate

a_0 - A constant used in the Linear Acceleration Method.

a_1 - A constant used in the Linear Acceleration Method.

a_2 - A constant used in the Linear Acceleration Method.

a_3 - A constant used in the Linear Acceleration Method.

a_4 - A constant used in the Linear Acceleration Method.

a_5 - A constant used in the Linear Acceleration Method.

c - Damping

c_{cr} - Critical Damping

E - Modulus of Elasticity for Glass (10.4×10^6 psi)

h - Window Plate Thickness

k - System Spring Force

k_e - Equivalent Spring Stiffness

K_L - Equivalent Load Factor

K_M - Equivalent Mass Factor

K_R - Equivalent Resistance Factor

F_e - Equivalent Force

F_{i+1} - Forcing Function at time i+1

F_r - Incremental Force on finite area of plate

F_t - Total Force on plate

$F(t)$ - Force as a function of time

m - Mass

m_e - Equivalent Mass

M_r - Incremental Mass on finite area of plate

m_t - Total Mass

P - Overpressure

P' - Modified peak blast pressure

q - Dimensionalized Load on Plate

q - Nondimensionalized Load

T' - Blast duration

t_i - Time at beginning of time step

t_{i+1} - Time at end of time step

y_0 - First peak displacement for Log Decrement equation

y_1 - Second peak displacement for Log Decrement equation

y_i - Displacement at beginning of time step

$\dot{y}_i$ - Velocity at beginning of time step

$\ddot{y}_i$ - Acceleration at beginning of time step

y_{i+1} - Displacement at the end of time step

y - Displacement

$\dot{y}$ - Velocity

$\ddot{y}$ - Acceleration

y(t) - Displacement as a function of time

$\ddot{y}(t)$ - Acceleration as a function of time

U - Blast velocity

$\hat{\delta}$ - Nondimensionalized Displacement

Δ - Dimensionalized Displacement of the Plate

Δt - Time step

$\Delta\ddot{y}_i$ - Change in acceleration at beginning of time step

Φ - Characteristic shape of displacement

Φ_r - Characteristic shape of displacement for finite area

π - PI (3.14159....)

σ - Dimensionalized Stress in the Plate

$\hat{\sigma}$ - Nondimensionalized Stress in the Plate

Σ - Summation

ξ - Damping Ratio C/C_{cr}

Introduction

Numerous facilities are constructed throughout the world which potentially could be subjected to blast loads. This includes not only military facilities and embassies, but also structures erected near explosive sources and structures which are subject to terrorist attacks or other accidental explosions. There are numerous publications which cover the design of structures to resist various types of blast loads, but few are applicable to the design of the windows. This is rather amazing because one of the major causes of casualties from an explosion (after the initial overpressure) is from high velocity fragments, and broken glass falls into this category. (1)

Often heat-treated glass, which possesses greater resistance to uniform lateral loads than annealed glass, is used in structures which are intended to resist blast loads. While it is known that heat-treated glass is many times stronger than annealed glass, there are no well accepted design techniques for the use of heat-treated glass in blast situations. Most heat-treated glass design procedures presented in manufacturer's literature and building codes are based upon approaches which were intended to be used for the design of glass subjected to the effects of severe wind storms. In the case of severe wind storms, loads rarely exceed 200 psf and it is generally assumed

that design wind loads have a duration of 60 seconds. The magnitudes of blast loads can be much greater than 200 psf, and the duration of blast loads are generally much less than 60 seconds. Therefore, it is not proper to use existing glass design procedures for blast resistant glass design.

The results of this research provide a dynamic analysis which ultimately can be used for the design of blast resistant glass.

Research Plan

The purpose of this research is to develop a method to reduce the response of heat-treated glass subjected to blast loads to a single degree of freedom system which can be analyzed using a simple dynamic approach. A computer code designed to satisfy these requirements has been developed by the author and is presented in this paper as an acceptable method to ascertain the dynamic response of rectangular windows subjected to various blast loads. To demonstrate the accuracy of this method the results generated by the author's code, hereafter referred to as WINBLAST, are compared to the results of a detailed finite element analysis using ABAQUS (2), and actual test data compiled by the Waterways Experimentation Station in Vicksburg, Mississippi. (3)

Previous Research

Nonlinear Response of Rectangular Glass Plates

Glass plates commonly undergo deflections which are well in excess of their thickness prior to failure. When plate deflections exceed half of the plate thickness, a geometrically nonlinear plate analysis must be used to model the plate response. (4) When a plate experiences geometric nonlinear behavior, boundary conditions become significant in determining the response of the plate. Geometrically nonlinear plate analysis is highly complex. It is further complicated by the often unique nature of boundary restraints associated with window installations. For this reason the problem of glass plate analysis has not been well addressed in classical plate texts for static or dynamic response. (4)

Beason has shown through comparisons of experimental and analytical data that the case where the glass plate edges are simply supported and free to slip in-plane provides a reasonable design model. (4) These are the boundary conditions used in this report and WINBLAST.

Beason has used a modified version of a finite difference plate solution developed by Vallabhan and Wang (5) to produce a massive data base for the static performance of glass plates. These data are used by the author to establish assumed deflected shapes for various sized plates so that equivalent masses,

equivalent masses, forces, and stiffnesses can be developed for plate with aspect ratios between 0.2 and 5.0. This procedure will be explained in further detail after a review of the equivalent system response technique.

Blast Theory

The blast effects of an explosion create a shock wave composed of a high-pressure shock front which expands outward from the center of the detonation. The intensity of the pressure decreases with distance from the detonation point and time. (1) The shock front travels with a velocity, U, and obtains a peak overpressure, P, which results in a peak pressure, P', on any structure in the blast's path. Figure 3-1 presents idealizations

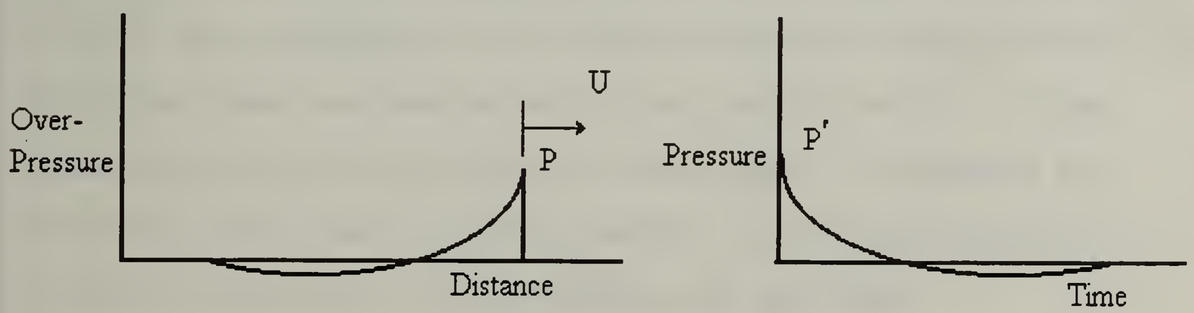


Figure 3-1. Blast Shapes

for the variation of blast pressures as a function of time and distance. (1)

When the shock front hits a window plate there is a diffraction effect as the plate reverses the direction of the

shock front and diverts the front around it. This results in the structure being subjected to a peak pressure which is larger than the peak overpressure. The overpressure results from an increase in air pressure immediately behind the shock front, while the peak blast pressure applied to structures in the blast's path includes the refraction effect discussed above. At the same time, air behind the shock front is moving away from the structure at a high velocity. This produces drag forces on the plate. (1) Detailed calculation procedures for estimating these pressures are presented in NAVFAC P-397 (1). For the purposes of this paper and WINBLAST, the magnitude of the peak blast pressure is assumed to be given.

Based on the above discussion, it can be seen that an explosion consists of much more than a simple high-impact load applied to the plate. While this is true, the effects of all but the diffraction and overpressure are generally considered to be minimal when compared to the diffraction and overpressure. (1) Therefore they are neglected in the current effort. The underlying principle is that if the plate is designed to withstand the blast's peak pressure, it should be able to withstand the other lesser effects of the blast.

Considering only the peak pressure, the forcing function, presented in Figure 3-1, can be idealized as a triangular load, as shown in Figure 3-2, where P' is the peak load experienced by the plate and T' is the duration of the idealized loading. For both the finite element analysis and WINBLAST a further

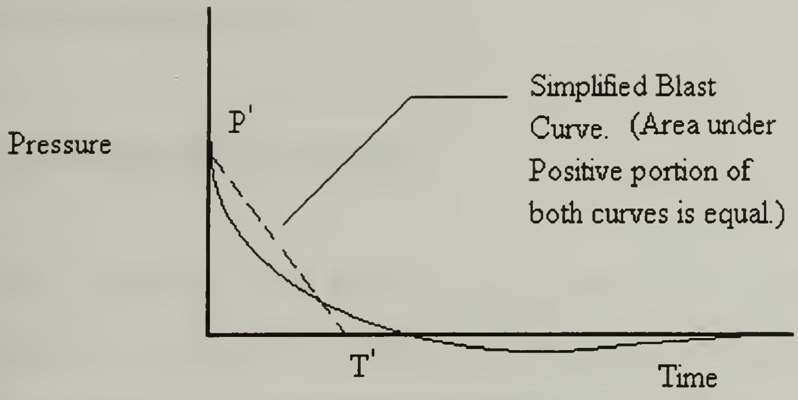


Figure 3-2. Simplified Blast Curve

modification to the simplified blast curve was made. As shown in Figure 3-3, the peak pressure has been offset by one millisecond to avoid the mathematical difficulty of the instantaneous acceleration which results from increasing the pressure on the plate from zero pounds per square inch to P' pounds per square inch over zero seconds. The area under the loading function presented in Figure 3-3 continues to be equal to the area under

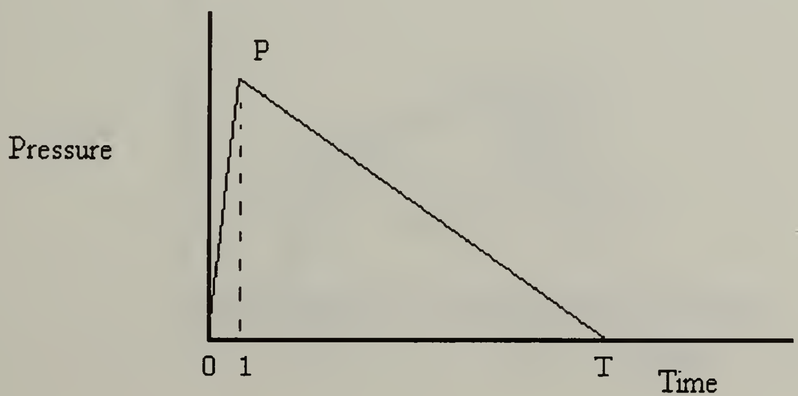


Figure 3-3. Modified Blast Curve

the positive pressure portion of the pressure-time relationship presented in Figure 3-2.

Linear Acceleration Method

A blast loading on a plate will result in a dynamic response of the plate. Perhaps the simplest method of dynamic analysis is the linear acceleration method which employs the basic equation of motion given in equation (1).

$$m\ddot{y} + c\dot{y} + ky = F(t) \tag{1}$$

where m = mass, c = damping, k = resistance, $\ddot{y}$ = acceleration, $\dot{y}$ = velocity, y = displacement, and F(t) = force. The method assumes a linear acceleration during a fixed time interval, Δt, as shown graphically in Figure 3-4. (6) Letting t_i and t_{i+1} be, respectively, the designation for the time at the beginning and

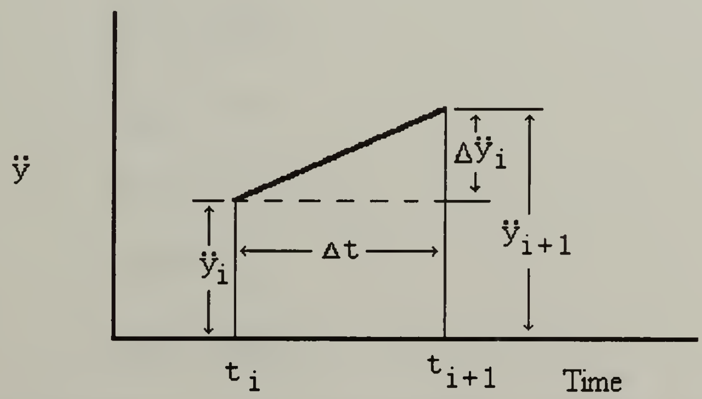


Figure 3-4. Linear acceleration during time interval

end of the time interval Δt, the acceleration, $\ddot{y}(t)$, can be expressed numerically as:

$$\ddot{y}(t) = \ddot{y}_i + (\Delta\ddot{y}_i/\Delta t)(t - t_i) \qquad (2)$$

where $\ddot{y}(t)$ represents the acceleration at any time t, $\ddot{y}_i$ represents the acceleration at the beginning of the time interval, and $\Delta\ddot{y}_i$ represents the change in acceleration over the interval.

Integrating equation (2) twice to obtain an expression for displacement, y(t), gives:

$$y(t) = y_i + \dot{y}_i(t-t_i) + \ddot{y}_i(t-t_i)^2/2 + (\Delta\ddot{y}_i/\Delta t)(t-t_i)^3/6 \qquad (3)$$

Further manipulation of equations (1), (2), and (3) results in the condensed equation:

$$(a_0m + a_1c + k)y_{i+1} = F_{i+1} + m(a_0y_i + a_2\dot{y}_i + a_3\ddot{y}_i) + \\ + c(a_1y_i + a_4\dot{y}_i + a_5\ddot{y}_i) \qquad (4)$$

Where,

$$a_0 = 6/\Delta t^2 \qquad (5)$$

$$a_1 = 3/\Delta t \qquad (6)$$

$$a_2 = 6/\Delta t \qquad (7)$$

$$a_3 = 2 \qquad (8)$$

$$a_4 = 2 \qquad (9)$$

$$a_5 = \Delta t/2 \qquad (10)$$

Complete formulation of this method can be found in Paz. (6) With the above expressions, displacements can now be numerically

calculated once a time step, Δt, is chosen. Δt must be chosen such that the variation of deflection over the time step is small. If the chosen time step is too large then the solution will not converge to the steady-state vibrations. For WINBLAST and ABAQUS analysis a Δt of 0.0001 seconds was used.

Approximate Equivalent System

Biggs has presented a method to reduce an infinite degree of freedom system to a single degree of freedom system having the parameters of F_e (Force Equivalent), m_e (Mass Equivalent), and k_e (Spring Equivalent). (7) This method was first introduced in an Army Corps of Engineers Manual as a simplified method to determine responses of structural members subjected to atomic blasts. (8) The basis of this method is to reduce the system to an equivalent one degree of freedom system, as shown in Figure 3-5. Figure 3-5 (a) shows a fixed beam along with its corresponding equivalent one degree of freedom system. Figure 3-5 (b) and (c) show similiar conversions for a frame structure and a plate respectively.

In order to develop the equivalent systems, a characteristic shape (Φ) of the lateral deflection must be known. The characteristic deflected shape, Φ, is a function which allows the deflection at any given point to be related to the deflection at any other point. To define Φ using a discrete idealization,

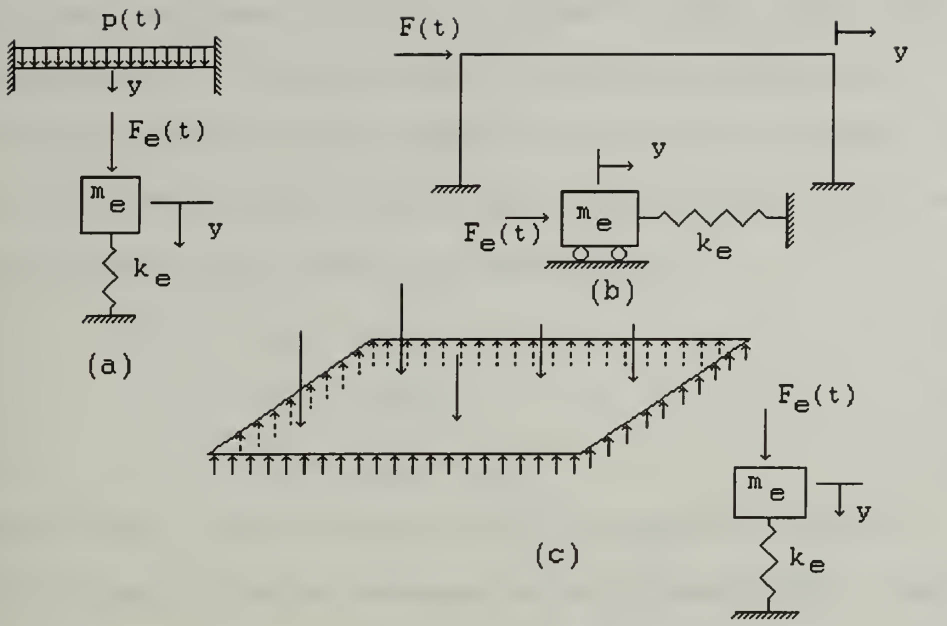


Figure 3-5. Equivalent one-degree systems.
(a) Fixed Beam, (b) Frame, (c) Plate

the structural member in question is divided into a number of discrete segments. Each segments' deflection is then divided by the deflection at the base point. The base point is usually associated with the maximum deflection of the member. The resulting values become the Φ values used in equations (11) and (12).

$$m_e = \Sigma M_r \Phi_r^{\,2} \tag{11}$$

$$F_e = \Sigma F_r \Phi_r \tag{12}$$

where n is the total number of discrete segments, M_r is the mass of the discrete segment, and F_r is the force applied to the discrete segment.

Equations (11) and (12), presented in Biggs (7), are simplified expressions derived from the Corps of Engineers formulation which relates the total strain energies of the actual

and equivalent systems. They are based on the requirement that the displacement of the equivalent system be identical to the maximum displacement of the actual system at all times. (8) WINBLAST utilizes a mass factor (K_M), load factor (K_L), and resistance factor (K_R) which are defined as:

$$K_M = m_e/m_t \tag{13}$$

$$K_L = F_e/F_t \tag{14}$$

$$K_R = k_e/k = K_L \tag{15}$$

Unlike Biggs, the factors used in WINBLAST vary as a function of load duration because of nonlinearities. Therefore, multiple equivalency factors need to be developed. These values vary as the plate deflects further into the nonlinear zone.

Once these equivalency factors are established they can be substituted into equation (1) to obtain:

$$K_M my + cy + K_L ky = K_L F(t) \tag{16}$$

or,

$$m_e y + cy + k_e y = F_e(t) \tag{17}$$

The multi-degree of freedom system is now reduced to a single degree of freedom system whose response can be described by equation (17). It must be noted that the magnitudes of the equivalency factors in equation (17) are all functions of displacement. The displacements at any point in time can be determined by utilizing the linear acceleration method to solve equation (4) numerically.

Formulation of Method

The procedure used by WINBLAST is to first convert the infinite degree of freedom glass plate system into an equivalent one degree of freedom system as proposed by Biggs and the Army. (7,8) Once this is accomplished, WINBLAST applies a linear acceleration analysis to determine the response of the plate in question.

In order to utilize this procedure, the characteristic deflected shape must be known. To determine the characteristic shape for glass plates, Beason utilized a modified version of a finite difference plate solution developed by Vallabhan and Wang (5) to determine the static deflections at 600 discrete point in various rectangular glass plates. Next, each deflection value was divided by the maximum deflection of the plate, in effect normalizing the deflections. In this way the deflection at any given point is related to the maximum deflection. Thus a characteristic shape is now defined by these 600 "normalized" deflections. This method of using static deflections to establish a characteristic shape was suggested by Biggs. (7) The author, of this paper, then used these normalized Φ values in equations (11) and (12) to calculate m_e and F_e. Once these values are determined the equivalent factors can be easily calculated using equations (13), (14), and (15).

This procedure was repeated numerous times to generate the equivalent factors for twenty-one nondimensionalized rectangular glass plates with aspect ratios between 1.0 and 5.0 with a 0.2 increment. Thirty one sets of equivalent factors were generated for each aspect ratio to fully describe the changing characteristic shape of the glass plate nonlinear geometries. Appendix E presents a tabulation of the equivalent factors for all aspect ratios considered in this report. Figure 4-1 shows the nonlinear relationship between the peak deflections and applied load on a square plate. Figures 4-2 and 4-3 show the relationship between the equivalent values and the non-dimensionalized loads for square glass plates.

The only remaining value which must be calculated before applying the linear acceleration method is the resistance in the plate. This resistance, or "spring constant", is only constant in the linear zone. As the plate deflections increase past the linear zone the resistance increases nonlinearly. But, with the help of Figure 4-1 or the information in Appendix E, which presents deflections versus applied forces, the spring constant can easily be obtained by dividing the applied force by the resulting deflection. The values obtained by this simple load-over-deflection calculation represent the average plate resistance over the particular interval in question. Figure 4-4 shows the spring constant values as a function of displacement for a 40" x 40" square plate, 0.71" thick.

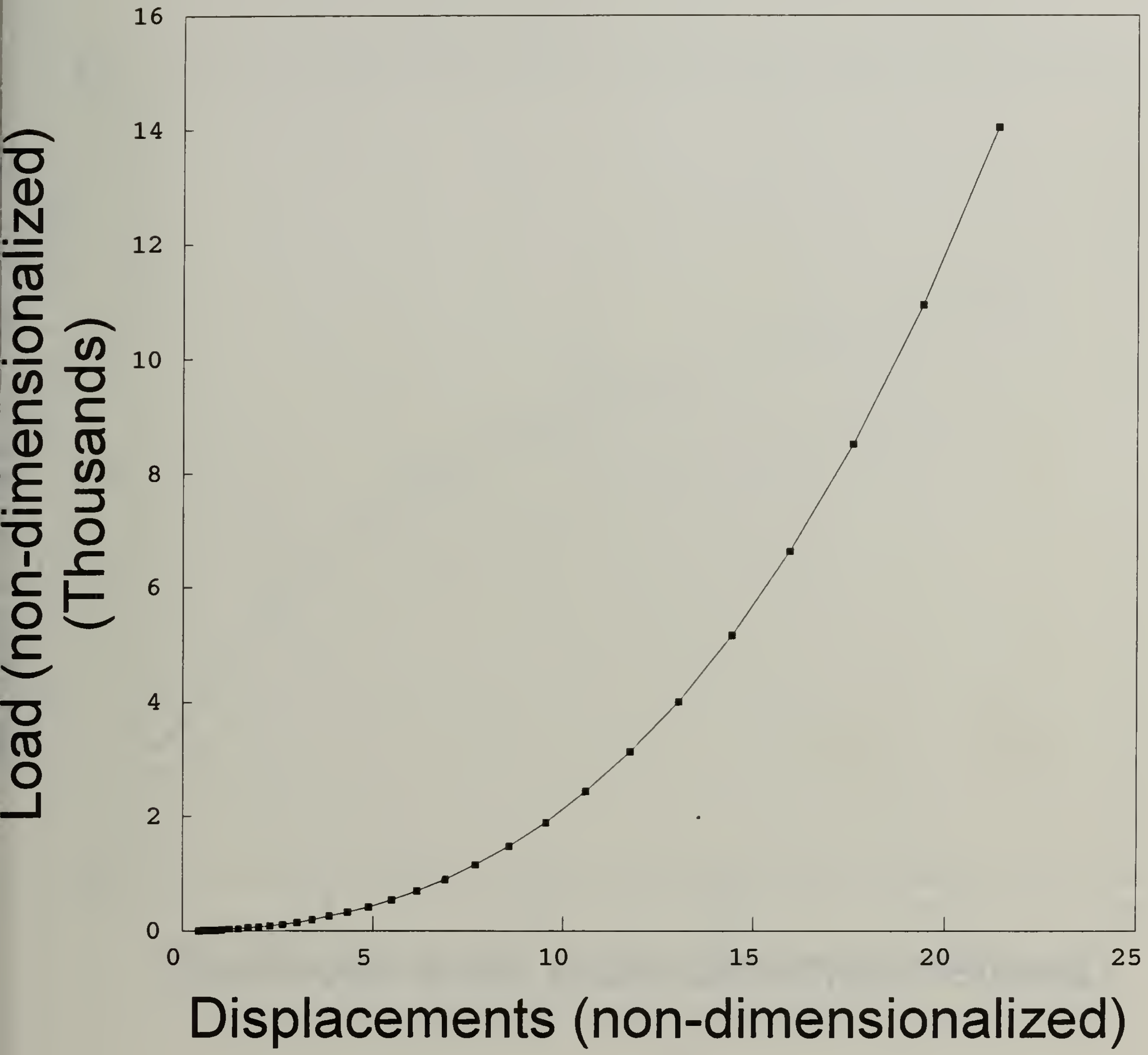


Figure 4-1. Displacements -vs- Load (Square Glass Plates)

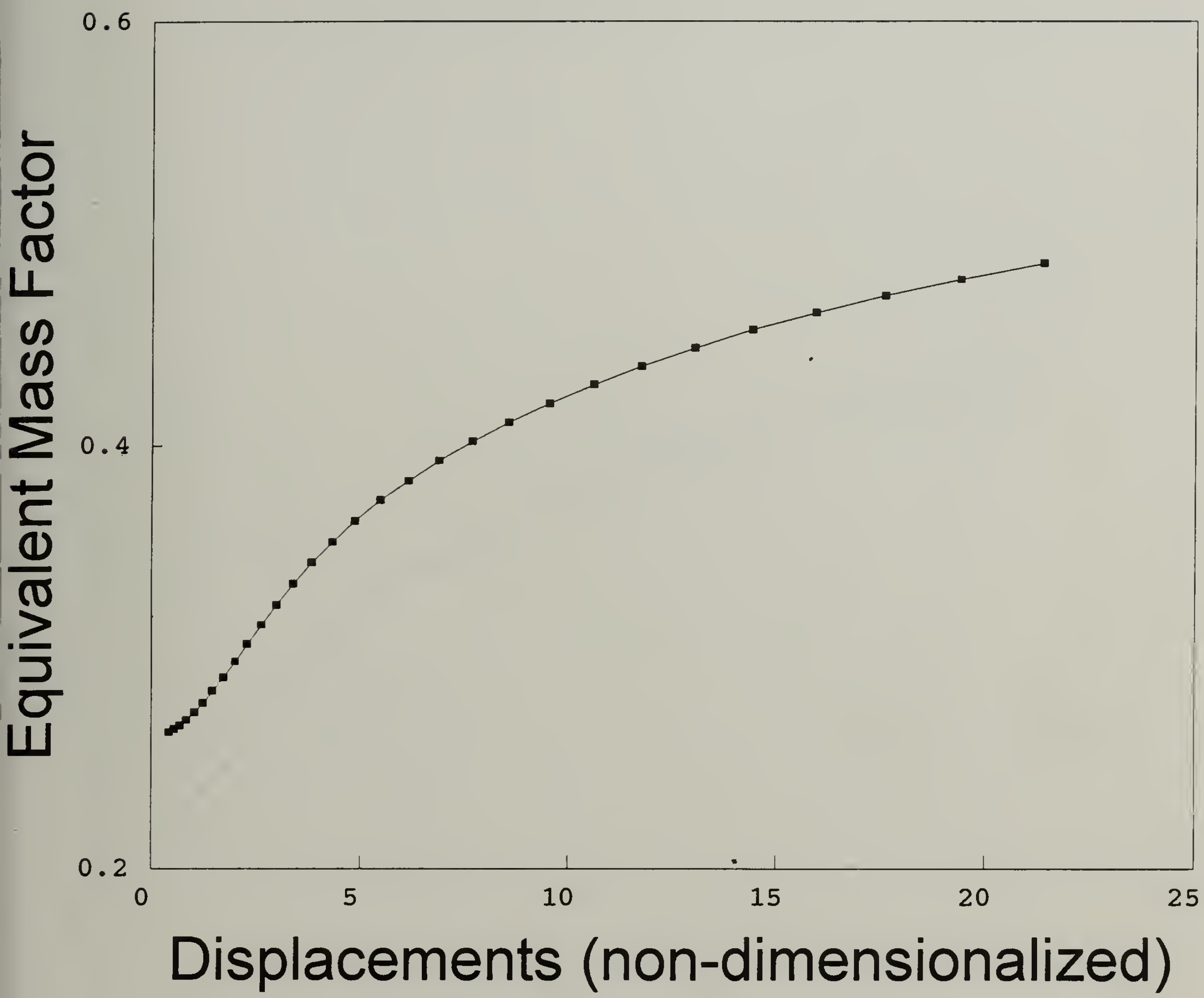


Figure 4-2. Equivalent Mass Factor (Square Glass Plates)

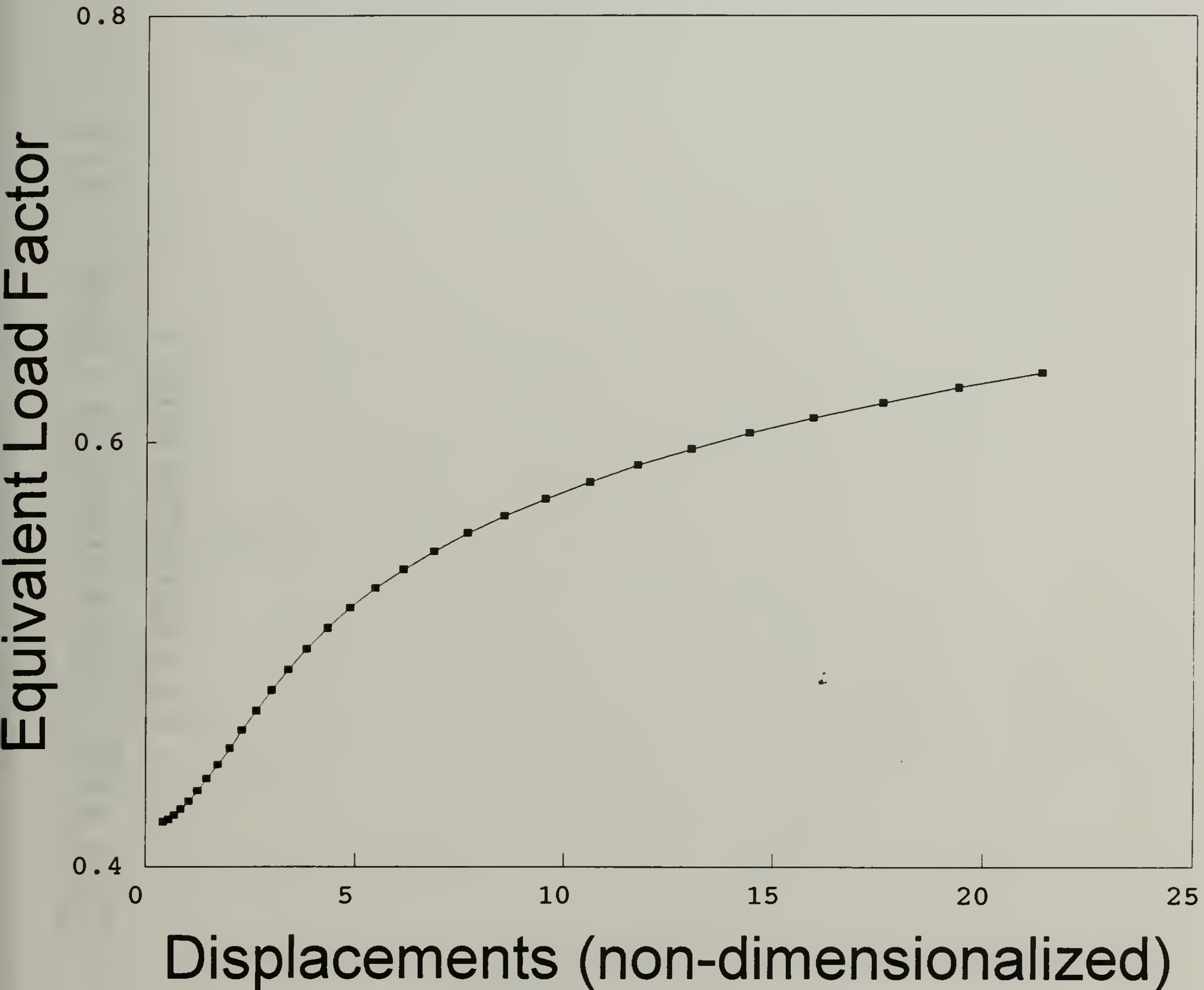


Figure 4-3. Equivalent Load Factor (Square Glass Plates)

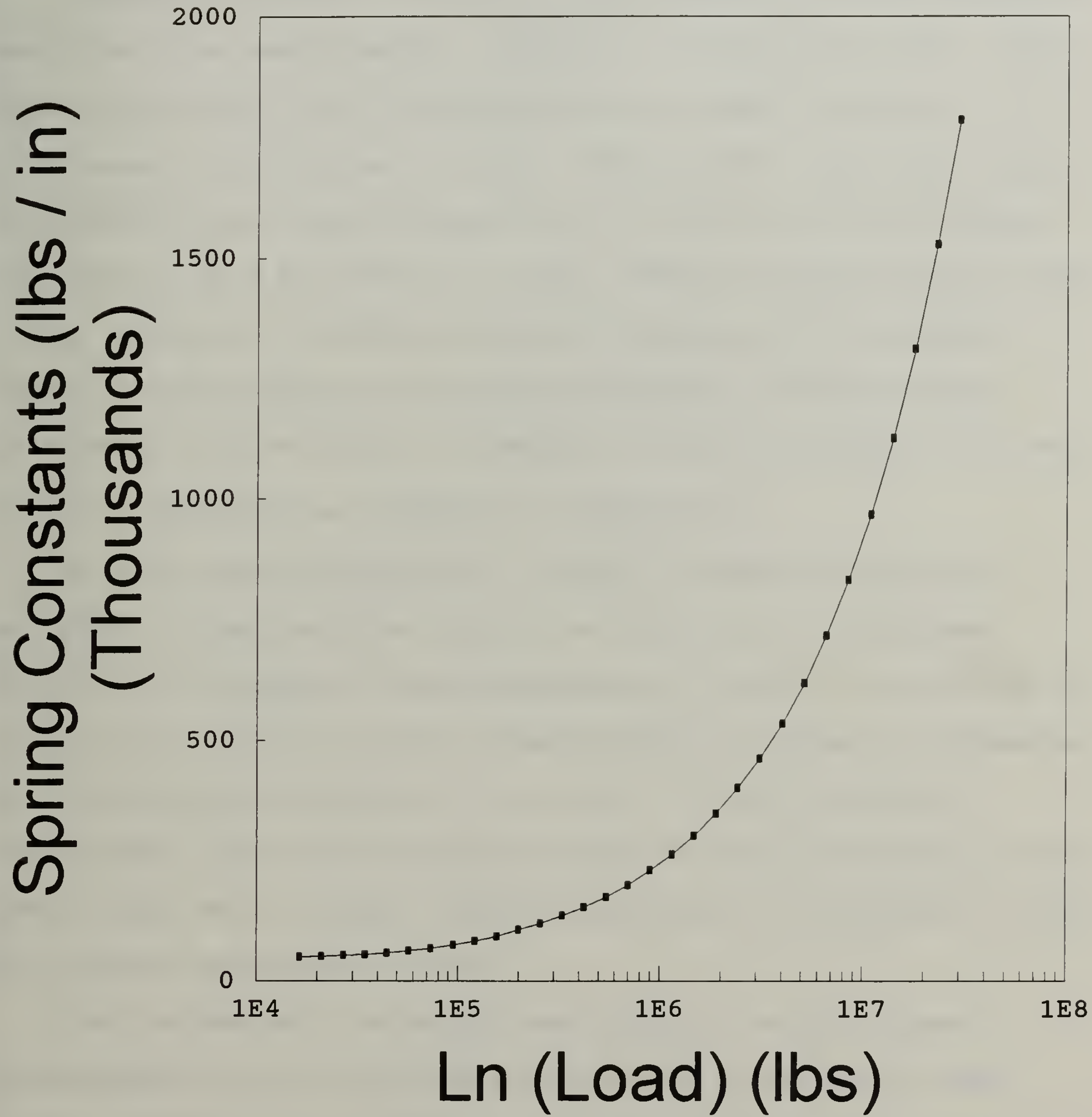


Figure 4-4. Spring Constant -vs- Load for a 40" x 40" Window

Having compiled the master data set (Appendix E) and being able to calculate plate resistance, WINBLAST can now enter into its dynamic analysis and determine the deflections for any uniform loading on any rectangular plate.

WINBLAST requires the input of the window size and thickness and blast size and duration, damping is an optional item. Total dynamic analysis time is also input as an output control. It then reads in the values of load, displacement, equivalent mass, equivalent force, and stresses from the master data and stores the data in 31 x 21 matrices. Next, WINBLAST dimensionalizes the loads, stresses, and displacements, calculates the constants needed for the linear acceleration analysis, and the spring constants. A flow chart of WINBLAST is given in Figure 4-5, and a copy of the code is presented in Appendix A.

At this point the program is ready to begin the dynamic analysis. First the load applied to the plate is calculated based on the standard blast approximation function illustrated in Figure 3-3, then the current displacement is checked to determine which equivalent values are to be used. If the calculated displacement does not correspond to any of the data points in the master data set, a simple linear interpolation is applied to find the correct equivalency values.

The incremental changes in acceleration, velocity, and displacement are now calculated and added to the stored total values. Every ten increments (or every millisecond) the data are printed out.

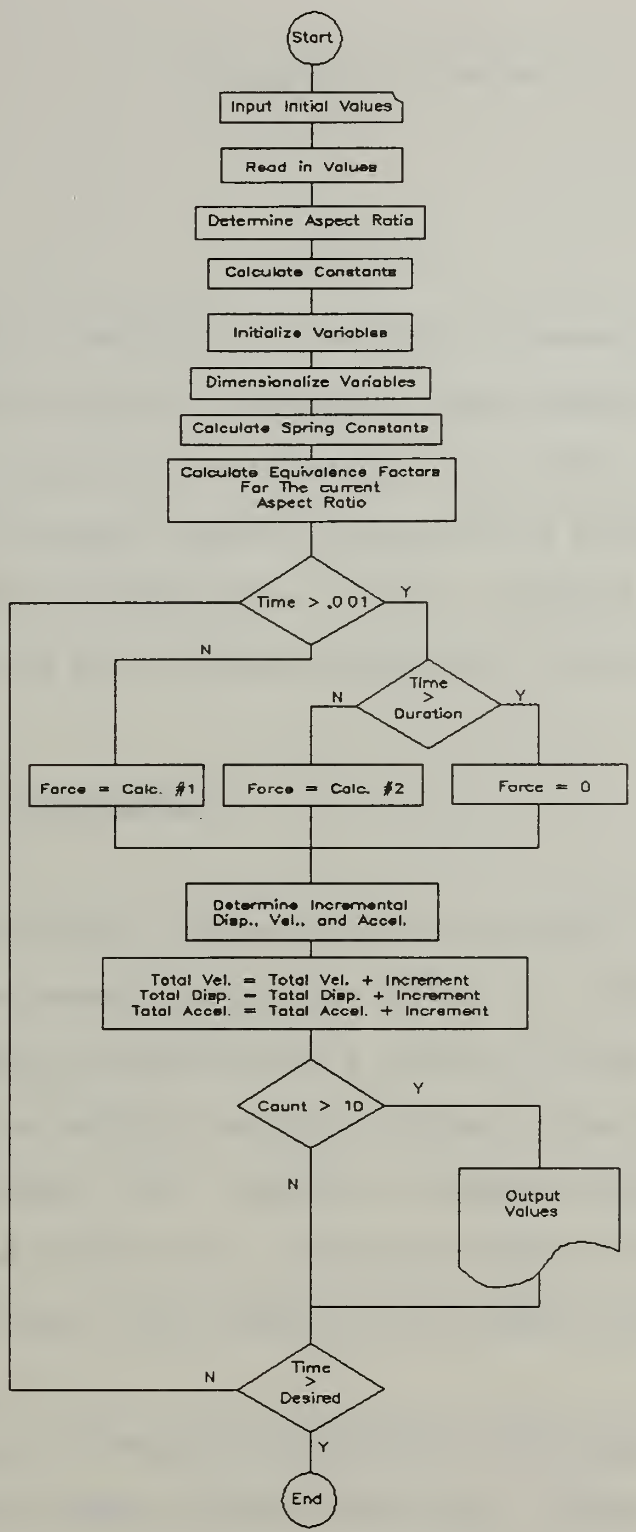


Figure 4—5. Flowchart for WINBLAST

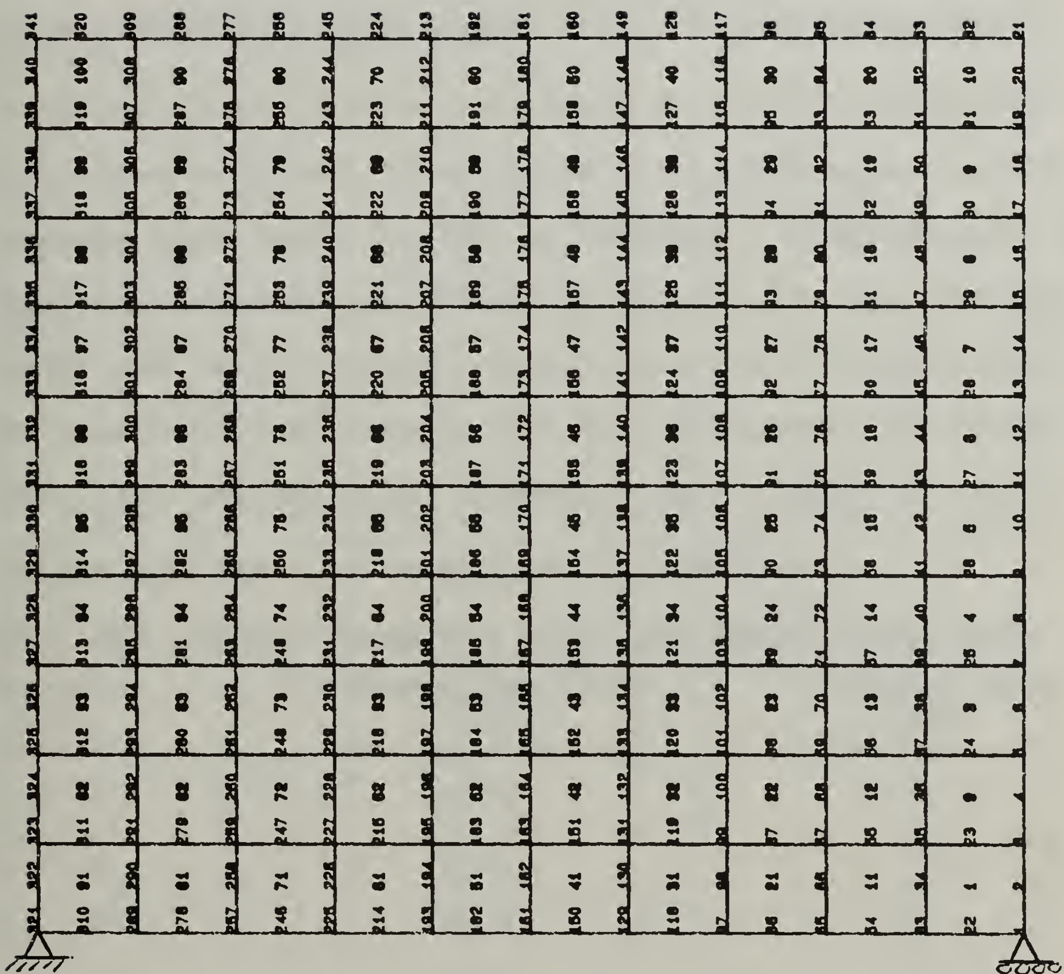
Evaluation of Method

To validate WINBLAST, it is first compared to the finite element computer results generated using ABAQUS. (2) This program was used in conjunction with PATRAN (9) (also a computer application) to model window plates as 100 element meshes. Then the results from WINBLAST are further compared to experimental data compiled by the Waterways Experiment Station. (3)

WINBLAST -vs- ABAQUS

ABAQUS was used to model the glass window plates as 100 element meshes using the element S8R5. (2) This element is an eight-noded shell element with a reduced 5-node integration feature. It is perhaps the most commonly used shell element in the ABAQUS library. (2) Figure 5-1 shows a graphical model, produced using PATRAN (9), of the mesh used in analysis. A sample of the input code used for the ABAQUS analysis is located in Appendix B.

The boundary conditions previously discussed were input by fixing all the edges in the z-direction, fixing one corner from displacements in all directions, and preventing y-direction displacement of the adjacent corner (see Figure 5-1). The load was applied as shown in Figure 3-3, and maximum displacements



Note: Plate fixed against Z-direction deflection along all edges.

Figure 5-1. Finite Element Model

versus time was output. The duration of the loads was chosen as 26 milliseconds. This duration corresponds to the calculated duration of similar loads used in the experimental data. (3) No damping is included in this ABAQUS -vs- WINBLAST comparison.

A total of 11 windows were analyzed to validate WINBLAST. The first three windows correspond to the window sizes tested by the Waterways Experiment Station in Vicksburg, Mississippi. The remaining eight windows are chosen to demonstrate the versatility of WINBLAST, as they represent larger plates and larger loads. Thus they serve as verification for various aspect ratios and loads well into the nonlinear response zone. Table 5-1 shows the window sizes analyzed for comparison with ABAQUS.

Table 5-1. Window Sizes and Loads for ABAQUS Comparison

Window Size (in)	Window Thickness (in)	Applied Load (psi)
26 x 26	0.71	14.6
36 x 36	0.71	14.6
40 x 40	0.71	14.6
72 x 72	1.06	14.6
72 x 72	1.06	30.0
72 x 72	1.06	40.0
72 x 72	1.06	50.0
72 x 24	0.71	75.0
72 x 24	0.71	14.6
32 x 20	0.71	14.6
27 x 20	0.71	14.6

Table 5-2 presents a comprehensive comparison of the peak deflections predicted by WINBLAST and ABAQUS showing the total differences in deflections both in total inches and as a percentage of the WINBLAST output.

Table 5-2. ABAQUS -vs- WINBLAST Peak Deflections

Window Size (in)	Thick-ness (in)	Load (psi)	ABAQUS Deflection (in)	WINBLAST Deflection (in)	Diff. (in)	Diff. (%)
26 x 26	0.71	14.6	0.1599	0.1500	-0.0099	-6.6
36 x 36	0.71	14.6	0.5417	0.5307	-0.011	-1.9
40 x 40	0.71	14.6	0.7706	0.7603	-0.0103	-1.4
72 x 72	1.06	14.6	1.888	1.8751	-0.0129	-0.7
72 x 72	1.06	30.0	3.003	3.0464	0.0434	1.5
72 x 72	1.06	40.0	3.535	3.6208	0.0858	2.4
72 x 72	1.06	50.0	3.991	4.1127	0.1217	3.1
72 x 24	0.71	14.6	0.3749	0.3390	-0.0359	10.6
72 x 24	0.71	75.0	1.776	1.6867	-0.0893	-5.3
32 x 20	0.71	14.6	0.1143	0.1093	-0.005	-4.6
27 x 20	0.71	14.6	0.09266	0.0867	-0.006	-6.9

Table 5-2 shows a very close relationship between WINBLAST's one-degree of freedom model and a detailed multi- degree of freedom finite element model. WINBLAST is off by the largest percentage (although a minute total distance) when the window deflections are small and the plate remains linear. However, as

the deflections (and failure probability) increase, so does the accuracy of WINBLAST.

The complete data generated from WINBLAST for the 72" x 72" window subjected to the 14.6 psi load can be found in Appendix C, along with all the other WINBLAST results. In addition, the results are presented graphically on the following pages in Figure 5-2 (Displacements), Figure 5-3 (Velocities), Figure 5-4 (Accelerations), and Figure 5-5 (Stresses). Figure 5-6 shows a graphical comparison of deflections between WINBLAST and the finite element analysis, ABAQUS. The two solutions are nearly identical. These results verify the dynamic analysis from a theoretical standpoint. All output generated by ABAQUS is located in Appendix D.

WINBLAST -vs- Experimental Data

The purpose of this section is to compare WINBLAST's output with experimental data. Table 5-3 shows the window sizes tested by the Waterways Experiment Station. (3) The thicknesses shown in Table 5-3 correspond to the average measured thicknesses of the windows.

Previous results were generated assuming no damping. However, real windows are damped and therefore damping has now been included in the peak deflections generated by WINBLAST and presented in Table 5-4.

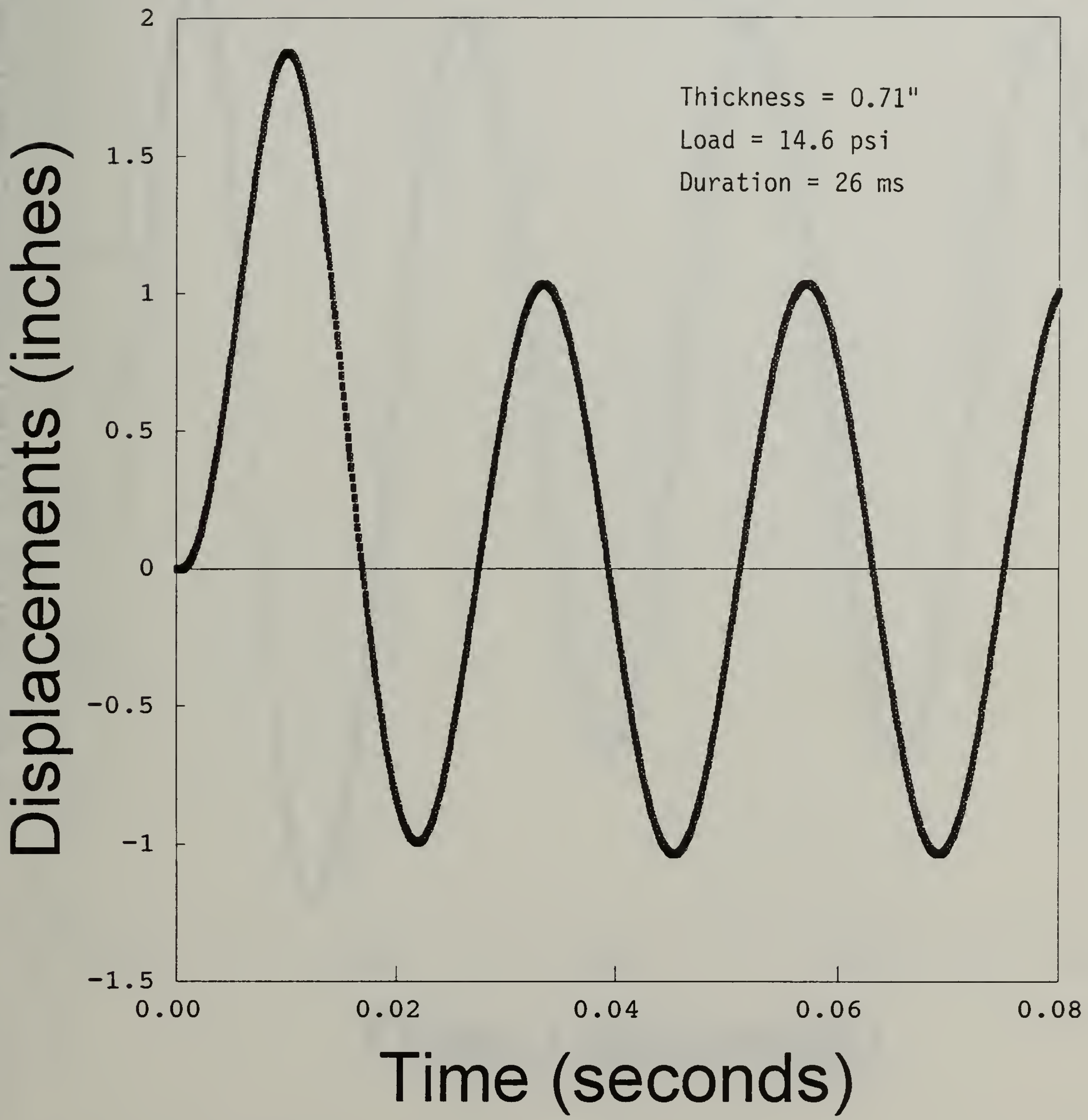


Figure 5-2. Displacements of a 72" x 72" Window Plate

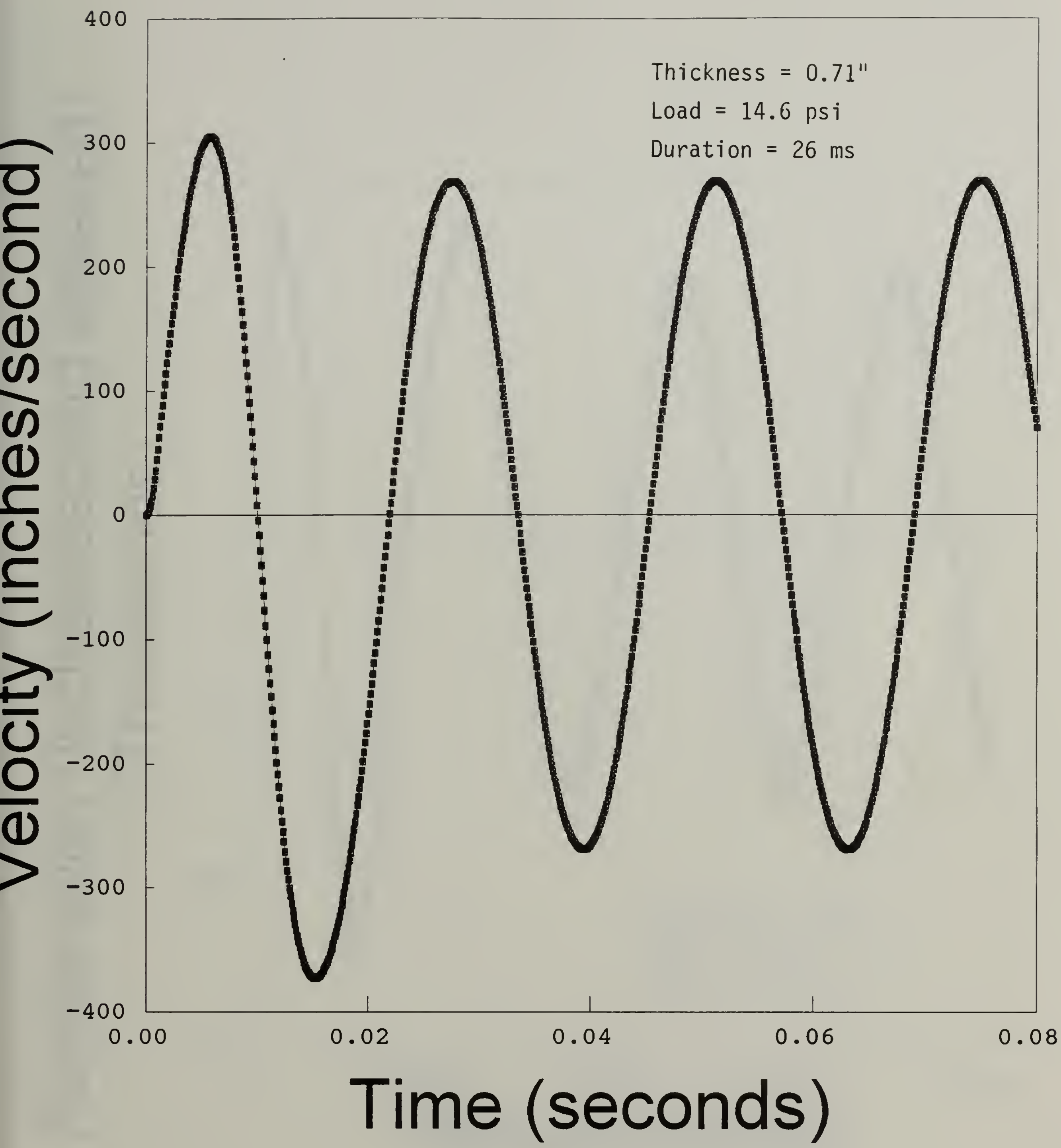


Figure 5-3. Velocity of a 72" x 72" Window Plate

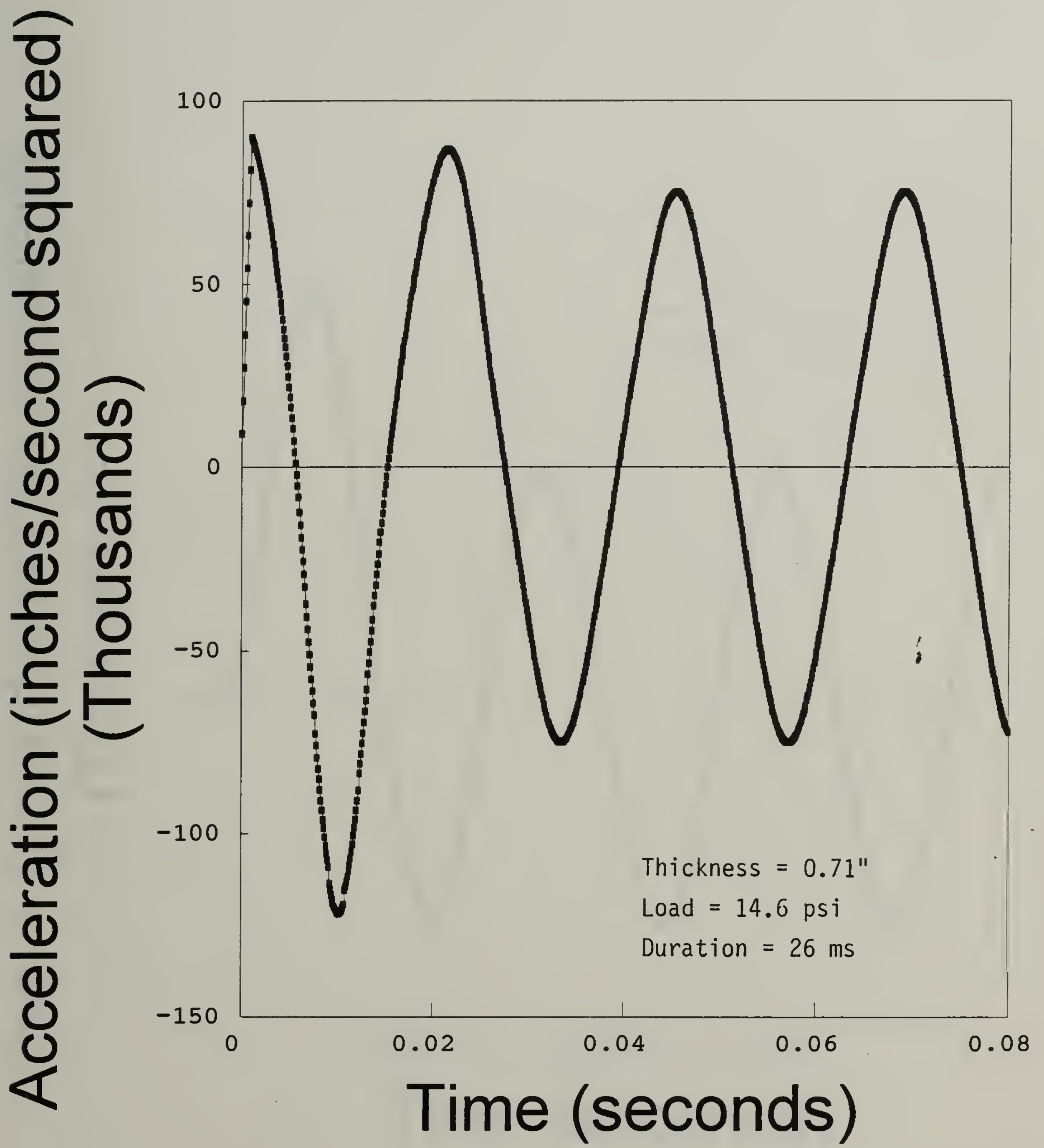


Figure 5-4. Accelerations of a 72" x 72" Window Plate

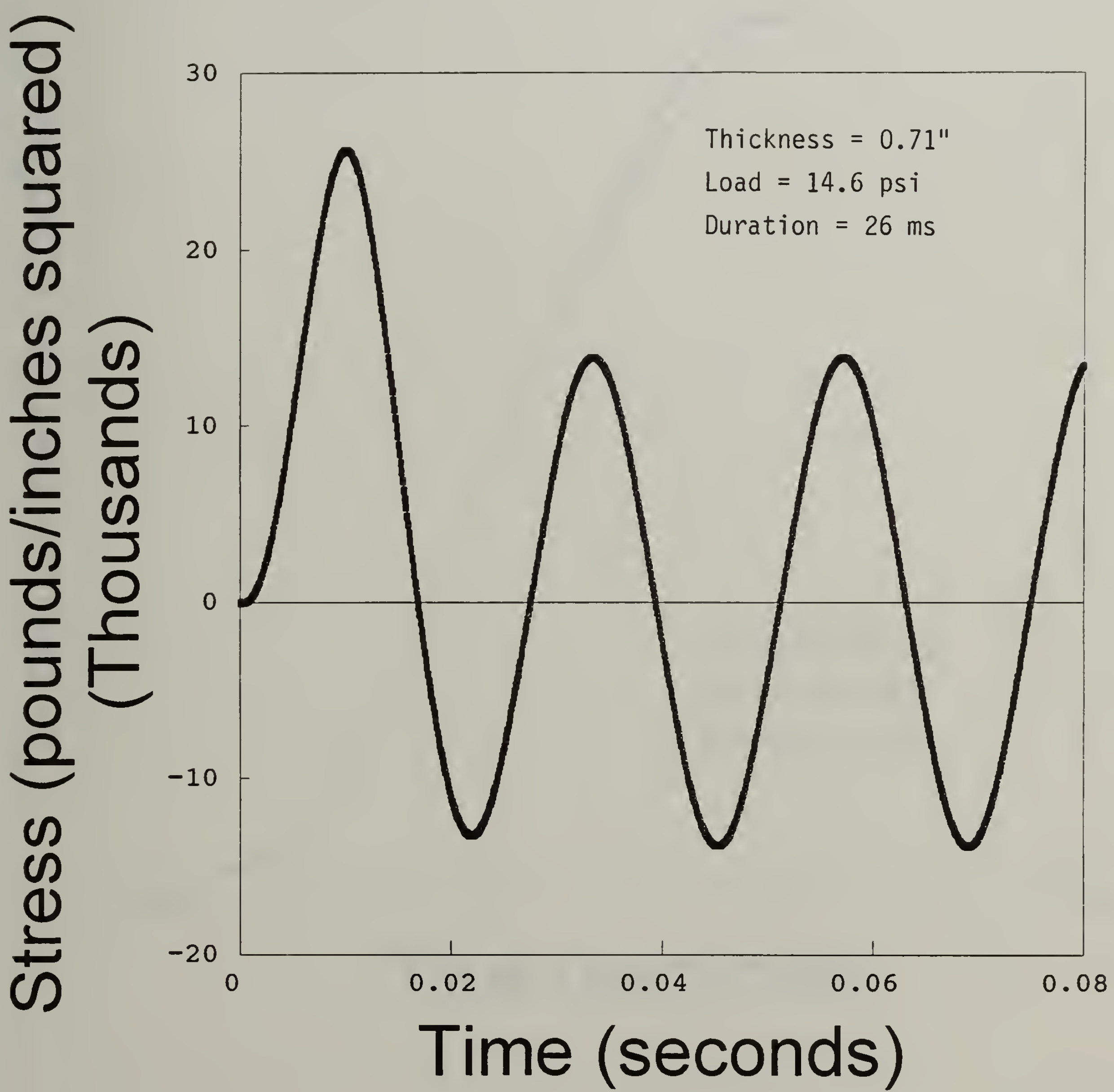


Figure 5-5. Stresses of a 72" x 72" Window Plate

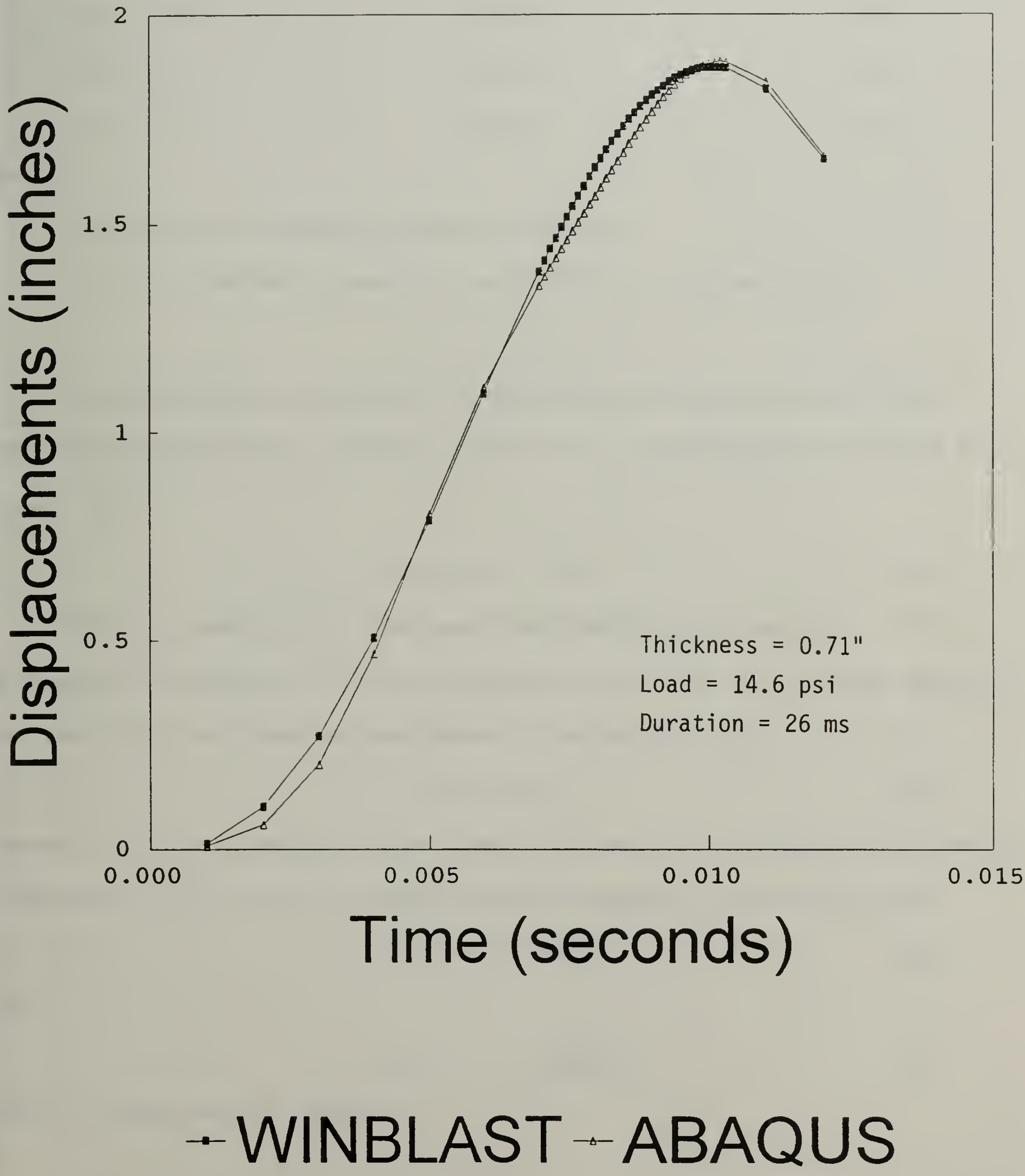


Figure 5-6. WINBLAST -vs- ABAQUS for a 72" x 72" Window Plate

Table 5-3. Waterways Experiment Station Test Windows

Window Size (in)	Window Thickness[a] (in)	Applied Load[b] (psi)
26 x 26	0.819	14.6
26 x 26	0.783	14.6
36 x 36	0.813	14.6
36 x 36	0.806	14.6
40 x 40	0.808	14.6

Notes:

(a) Overall average window thickness

(b) Calculated pressure load based on applied blast

To determine the amount of damping in the windows of the Waterways Experiment Station report the log decrement method was used. (6)

$$\ln(y_0/y_1) = 2\pi\xi \tag{18}$$

Where y_0 and y_1 are the peak deflections of any two successive peaks and ξ is the damping ratio of the system damping to the critical damping as shown in equation (19):

$$\xi = C/C_{cr} \tag{19}$$

where C is the damping value used in the basic equation of motion (equation (1)) and C_{cr} (the critical damping) is defined as:

$$C_{cr} = 2\ (\sqrt{km}\ ) \tag{20}$$

or,

$$C_{cr} = 2\ (\sqrt{k_e m_e}\ ) \tag{21}$$

for our equivalent system.

Figure 5-7 shows a the log decrement method graphically.

A complete derivation and analysis of the log decrement method is presented in Paz. (6)

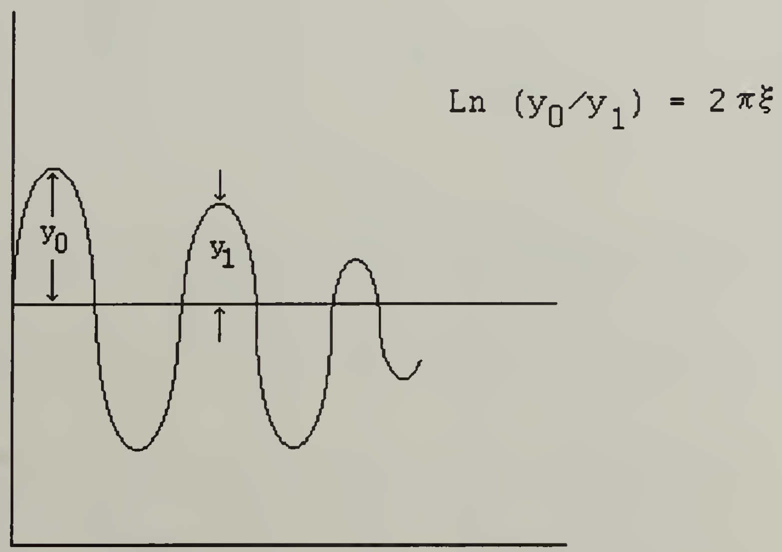
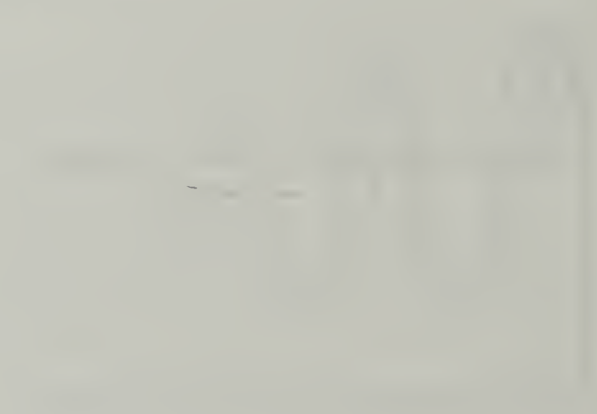


Figure 5-7. Graphical Log Decrement Method

The Waterways Experiment Station Report (3) included graphic plots of the measured deflections versus time. These were used to calculate the damping in the window systems used. Figure 5-8 presents a sample plot taken from the report. Using the log decrement method on Figure 5-8 and the other figures in the Waterways Experiment Station Report, the average damping value was approximately 4% so Table 5-4 includes 4% damping.



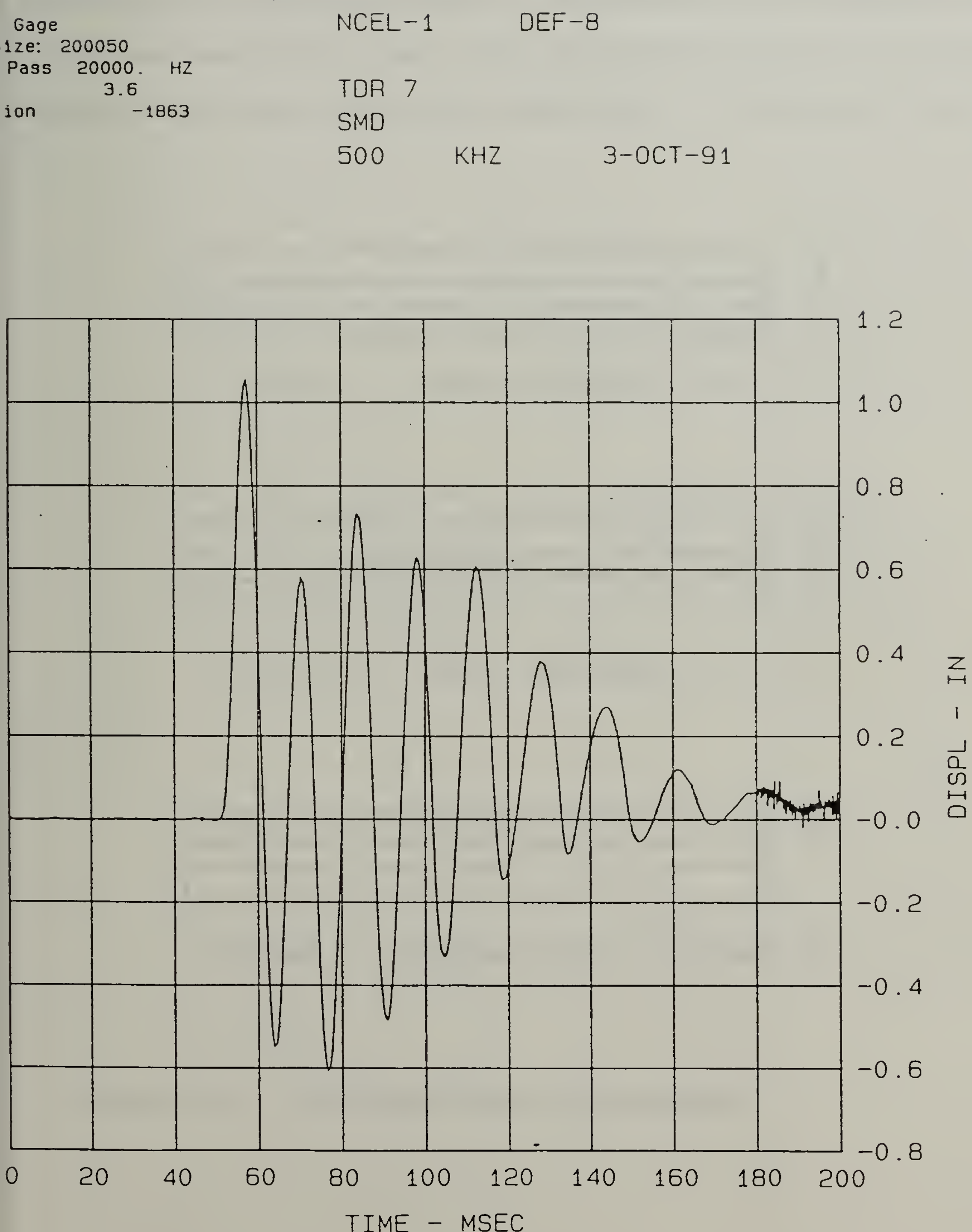


Figure 5-8. Sample Graphical Output of Experimental Data

The windows tested by the Waterways Experiment Station were laminated windows composed of two 3/8" thick window plates. There are currently three ways, as illustrated in Figure 5-9, which have been suggested to determine an equivalent monolithic thickness for laminated glass. Method one is to assume the glass to be one monolithic plate with thickness equal to the entire overall thickness (glass and innerlayer). Method two is to

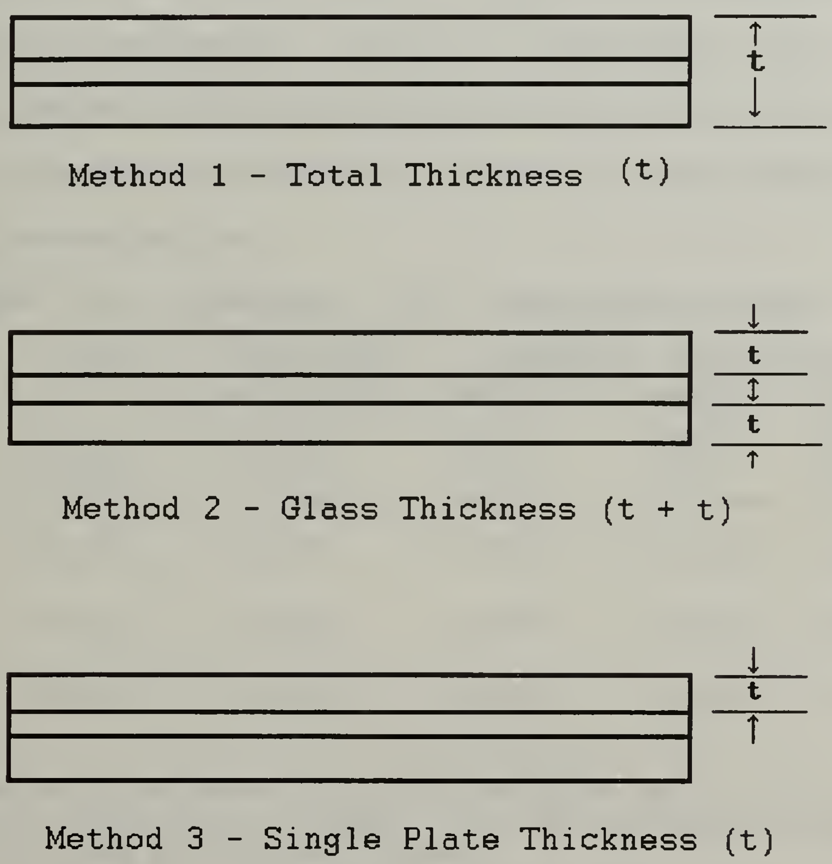
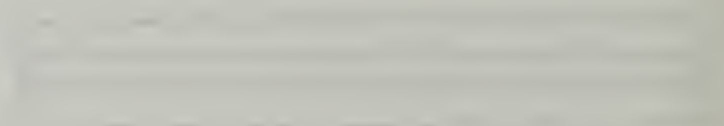


Figure 5-9. Laminated Glass Thicknesses



assume the glass plate is a monolithic plate with thickness equal to the sum of the glass thicknesses only. Method three is to assume that the glass plate consists of two independent, stacked plates which share the load equally. Methods one and three provide performance bounds for the laminated plate. There is evidence to believe that method two provides realistic displacement performance but its relevance to overall strength is still uncertain. (10)

All three methods were used as input into WINBLAST to examine their performance. Table 5-4 presents a peak deflection comparison between the experimental data from the Waterways Experiment Station and WINBLAST, using all three methods of thickness determination.

Table 5-4. WINBLAST - vs - Experimental Data

Window Size (in)	Load (psi)	Test Data[a] Deflection (in)	WINBLAST Deflections[b] Method One[c] (in)	Method Two[d] (in)	Method Three[e] (in)
26 x 26	14.6	0.15	0.0981	0.1414	0.4890
36 x 36	14.6	0.555	0.3475	0.5013	1.1296
40 x 40	14.6	0.685	0.5182	0.7205	1.4138

a. Deflections shown are the measured deflections averaged over two separate tests. One or two deflection gages were used during each test.
b. All WINBLAST deflection values in this table include 4% damping.
c. Overall thickness (Glass and Innerlayer).
d. Glass thickness only.
e. Single plates sharing load equally.

Table 5-4 shows two things, first, that method two, using the thickness of the glass plates only, provides the most reasonable deflections, and second, it shows that the output generated by WINBLAST compares favorably to the test data. While it does not correspond as well as with the theoretical model (Table 5-2) it is still relatively close to the test data.

It should be noted that this author had no control or input into the Waterways Experiment Station tests and was not present during the tests. Therefore, no statement can be made regarding the accuracy of these data. It is not the intent of this paper to verify the Waterways Experiment Station testing procedures, but data on blasts on windows are limited, and some data are much better than no data at all. And since this author has no reason to doubt the accuracy of the Waterways Experiment Station data it has been used in this report as "reasonable test result data."

Numerous conditions could account for the up to 10% differences shown in Table 5-4, such as the actual blast pressure on the windows differing from the calculated value of 14.6 psi. Also the calculated duration of the blast of 26 milliseconds could easily vary based on the angle to the blast and the actual blast value. A myriad of other parameters could also have affected the data. As an example of this, the deflection gage readings for the 26" x 26" plate varied from 0.06 inches to 0.19 inches (over a 300% difference!). (3)

Conclusions

As shown above, WINBLAST provides a feasible approach to calculate the response of rectangular monolithic glass plates to uniform pressure loads. It is extremely quick, reasonably accurate, and does not require a large super-computer to run. The only draw back to this routine is that it can only be applied to rectangular plates. Non-rectangular plates cannot be input into WINBLAST. While this method only encompasses monolithic glass, as is shown, reasonable assumptions can be employed to allow the performance of laminated glass to be modeled as monolithic.

As the computer code expands in its applications and certain industrial uses are considered, additional user friendly routines should be included in the code. Modifications which should be considered include the ability to run multiple iterations before the program stops, a subroutine to calculate the design thickness of the window plates so that the input would be the measured thickness of the glass, and finally, some user-friendly routines to ask for input verification and some validity checks to allow re-entry of data rather than requiring an entirely new run.

The main thrust of future research should however, be toward using the output generated by WINBLAST to calculate equivalent loadings and durations which can be used for glass design.

In the meantime, it is recommended that WINBLAST be used as a reasonable method to determine deflections and stresses of an input rectangular window size for any uniform blast loading.

APPENDIX A: This appendix presents the computer code WINBLAST. The Code is written in BASIC.

```
EM ***********************************************************************
EM *                                                                     *
EM *                          WINBLAST                                   *
EM *      A COMPUTE CODE TO DETERMINE THE DISPLACEMENTS, VELOCITIES      *
EM *      ACCELERATIONS AND STRESSES IN HEAT TREATED GLASS PLATES        *
EM *      SUBJECTED TO UNIFORM LOADS USING AN EQUIVALENT SINGLE DEGREE   *
EM *      OF FREEDOM LINEAR DYNAMIC ANALYSIS.                            *
EM *      PROGRAMMED DY DANIEL T. MAGRO LT, CEC, USN - AUGUST 1993       *
EM *                                                                     *
EM ***********************************************************************

EM ***********************************************************************
EM *                                                                     *
EM * DESCRIPTION OF VARIABLES:                                           *
EM *                                                                     *
EM * EMASS       - EQUIVALENT MASS FACTORS                               *
EM * EDISP       - MAXIMUM PLATE DISPLACEMENTS CORRESPONDING TO THE      *
EM *               EQUIVALENT FACTORS IN "EDISP" AND "EFORCE"            *
EM * EFORCE      - EQUIVALENT FORCE FACTORS                              *
EM * ESPRING     - SPRING CONSTANTS CALCULATED FOR EACH CORRESPONDING    *
EM *               DISPLACEMENT IN "EDISP"                               *
EM * STRESS      - MAXIMUM PLATE STRESS CORRESPONDING TO "EDISP"         *
EM * LOAD        - LOADS APPLIED TO DEVELOPE THE DISPLACEMENTS IN        *
EM *               "EDISP"                                               *
EM * EQDISP      - MAXIMUM DISPLACEMENTS CORRECTED TO THE ACTUAL         *
EM *               ASPECT RATIO                                          *
EM * EQMASS      - EQUIVALENT MASS FACTORS CORRECTED TO THE ACTUAL       *
EM *               ASPECT RATIO                                          *
EM * EQFORCE     - EQUIVALENT FORCE FACTORS CORRECTED TO THE ACTUAL      *
EM *               ASPECT RATIO                                          *
EM * EQSPRING    - SPRING CONSTANT CORRECTED TO THE ACTUAL ASPECT        *
EM *               RATIO                                                 *
EM * EQSTRESS    - MAXIMUM PLATE STRESS CORRECTED TO THE ACTUAL ASPECT   *
EM *               RATIO                                                 *
EM * QMASS       - SYSTEM MASS USED IN DYNAMIC ANALYSIS                  *
EM * QFORCE      - SYSTEM FORCE USED IN DYNAMIC ANALYSIS                 *
EM * QSPRING     - SYSTEM SPRING CONSTANT USED IN DYNAMIC ANALYSIS       *
EM * QSTRESS     - PLATE STRESS RESULTING FROM DYNAMIC ANALYSIS          *
EM * F           - FORCE OF LOAD ON PLATE IN PSI                         *
EM * PFORCE      - PEAK FORCE ON ENTIRE PLATE RESULTING FROM "F"         *
EM * FORCE       - THE CALCULATED FORCE APPLIED TO THE GLASS PLATE AS    *
EM *               A FUNCTION OF TIME                                    *
EM * DURATION    - TOTAL DURATION OF THE BLAST LOADING                   *
EM * DESIRE      - THE TOTAL DYNAMIC ANALYSIS TIME                       *
EM * TIME        - THE TIME AT WHICH THE MAXIMUM DEFLECTION IS REACHED   *
EM * T           - THE CURRENT TIME IN THE DYNAMIC ANALYSIS              *
EM * LENGTH      - PLATE LENGTH                                          *
EM * LWIDTH      - THE PLATE WIDTH                                       *
EM * THICK       - THE PLATE THICKNESS                                   *
EM * RATIO       - THE ASPECT RATIO OF THE PLATE                         *
EM * J1          - ARRAY VARIABLE USED TO DESIGNATE THE ASPECT RATIO     *
EM *               IMMEDIATELY TO THE LEFT OF THE PLATE ASPECT RATIO     *
EM * J2          - ARRAY VARIABLE USED TO DESIGNATE THE ASPECT RATIO     *
EM *               IMMEDIATELY TO THE RIGHT OF THE PLATE ASPECT RATIO    *
EM * LEFT        - EQUIVALENT TO "J1" (SEE "J1" ABOVE)                   *
EM * FACTORJ1    - USED IN LINEAR INTERPOLATION BETWEEN ASPECT RATIOS    *
EM * FACTORJ2    - USED IN LINEAR INTERPOLATION BETWEEN ASPECT RATIOS    *
```

```
EM * DAMP         - PERCENTAGE OF DAMPING IN THE SYSTEM                  *
EM * DAMPING      - CRITICAL DAMPING OF THE SYSTEM                       *
EM * D            - DUMMY VARIABLE USED TO OUTPUT DAMPING VALUE          *
EM * DAMP1        - VALUE CALCULATED IN THE LINEAR ACCELERATION METHOD   *
EM *                WHICH IS MULTIPLIED BY THE CRITICAL DAMPING VALUE    *
EM * MAX          - MAXIMUM DEFLECTION OF THE PLATE                      *
EM * AREA         - AREA OF THE PLATE                                    *
EM * MASS         - MASS OF THE PLATE                                    *
EM * MASS1        - VALUE CALCULATED IN THE LINEAR ACCELERATION METHOD   *
EM *                WHICH IS MULTIPLIED BY THE TOTAL MASS OF THE SYSTEM  *
EM * DELTAT       - TIME STEP USED DURING THE DYNAMIC ANALYSIS           *
EM * TEST         - ABSOLUTE VALUE OF THE TOTAL DISPLACEMENT USED TO     *
EM *                DETERMINE CORRECT EQUIVALENT VALUES                  *
EM * DISTANCE     - DISPLACEMENT DISTANCE BETWEEN EQUIVALENT FACTORS     *
EM * DIST         - DISTANCE PLATE IS DEFLECTED INTO THE NEXT HIGHEST    *
EM *                EQUIVALENT FACTORS                                   *
EM * COUNT        - DUMMY VARIABLE USED TO CONTROL THE TOTAL OUTPUT      *
EM * SLOPES       - LINEAR SLOPE BETWEEN SPRING CONSTANT FACORS          *
EM * SLOPEF       - LINEAR SLOPE BETWEEN EQUIVALENT FORCE FACORS         *
EM * SLOPEM       - LINEAR SLOPE BETWEEN EQUIVALENT MASS FACORS          *
EM * SLOPER       - LINEAR SLOPE BETWEEN MAXIMUM STRESS VALUES           *
EM * R1           - VARIABLE USED DURING THE DYNAMIC ANALYSIS            *
EM * K1           - VARIABLE USED DURING THE DYNAMIC ANALYSIS            *
EM * TDISP        - TOTAL DISPLACEMENT OF THE WINDOW PLATE               *
EM * DDISP        - CHANGE IN DISPLACEMENT FROM ONE TIME STEP            *
EM * DISP1        - DISPLACEMENT CREATED DURING ANY GIVEN TIME STEP      *
EM * TVEL         - TOTAL VELOCITY OF THE PLATE                          *
EM * DVEL         - CHANGE IN THE VELOCITY FROM ONE TIME STEP            *
EM * TACCEL       - TOTAL ACCELERATION OF THE PLATE                      *
EM * DACCEL       - CHANGE IN ACCELERATION FROM ONE TIME STEP            *
EM * A0           - LINEAR ACCELERATION CONSTANT A0                      *
EM * A1           - LINEAR ACCELERATION CONSTANT A1                      *
EM * A2           - LINEAR ACCELERATION CONSTANT A2                      *
EM * A3           - LINEAR ACCELERATION CONSTANT A3                      *
EM * A4           - LINEAR ACCELERATION CONSTANT A4                      *
EM * A5           - LINEAR ACCELERATION CONSTANT A5                      *
EM * I, J, K, L   - COUNTER VARIABLES USED IN FOR-NEXT LOOPS             *
EM * M, R, S      - COUNTER VARIABLES USED IN FOR-NEXT LOOPS             *
EM * GRADIN       - FILE USED TO HOLD EQUIVALENT FACTORS FOR ALL RATIOS  *
EM * STR30        - FILE USED TO STORE ALL MAXIMUM STRESS VALUES         *
EM *                                                                     *
EM *******************************************************************

EM DIMENSION THE VARIABLES

IM EMASS#(31, 21), EDISP#(31, 21), EFORCE#(31, 21), ESPRING#(31, 21)
IM LOAD#(31), STRESS#(31, 21), EQSTRESS#(31)
IM EQMASS#(31), EQDISP#(31), EQFORCE#(31), EQSPRING#(31)

EM INPUT ALL VARIABLES

IPUT "BLAST PRESSURE (psi)     :  ", F#
IPUT "BLAST DURATION (msec)    :  ", DURATION#
IPUT "WINDOW LENGTH   (in)     :  ", LENGTH#
```

```
NPUT "WINDOW WIDTH    (in)     :  ", LWIDTH#
NPUT "GLASS THICKNESS (in)     :  ", THICK#
NPUT "SYSTEM DAMPING (4%=.04) : ", DAMP#
RINT "INPUT TOTAL ANALYSIS TIME DESIRED (IN MILLISECONDS)"
NPUT "USUALLY 6-15 ms WILL BE ADEQUATE TO REACH PEAK : ", DESIRE

EM  SET UP ALL LOAD, MASS, DISP., AND FORCE DATA

OR R = 1 TO 31
  READ LOAD#(R)
EXT R
PEN "I", #1, "A:GRADIN.PRN"
OR L = 1 TO 21
  FOR K = 1 TO 31
     INPUT #1, EMASS#(K, L), EDISP#(K, L), EFORCE#(K, L)
  NEXT K
EXT L
LOSE #1
PEN "I", #2, "A:STR30.DAT"
OR L = 1 TO 21
  FOR K = 1 TO 31
     INPUT #2, STRESS#(K, L)
  NEXT K
EXT L
LOSE #2

ATIO# = LENGTH# / LWIDTH#
F RATIO# < 1! THEN RATIO# = LWIDTH# / LENGTH#
# = 100# * DAMP#
# = 0
DISP# = 0
VEL# = 0
AX# = 0

EM  LPRINT THE INITIAL CONDITIONS

PRINT "                    INPUT DATA FOR WINBLAST PROGRAM:"
PRINT "               *******************************************"
PRINT "                      BLAST PRESSURE = "; F#; " psi   "
PRINT "                      BLAST DURATION = "; DURATION#; " msec"
PRINT "                      GLASS THICKNESS = "; THICK#; " in."
PRINT "                      WINDOW SIZE = "; LENGTH#; " x "; LWIDTH#
PRINT "                      ASPECT RATIO = "; RATIO#
PRINT "                      DAMPING PERCENTAGE = "; D#; " %"
PRINT
PRINT "        TIME       DISPLACEMENT     VELOCITY     ACCELERATION      STR
PRINT "        (sec)          (in)         (in/sec)      (in/sec2)         (p
PRINT "      --------     ------------     --------     ------------      ---

EM CALCULATE CONSTANTS

LTAT# = .00001#
# = 6# / (DELTAT# ^ 2#)
# = 3# / DELTAT#
# = 6# / DELTAT#
# = 2#
# = 2#
# = DELTAT# / 2#
```

```
EM CALCULATE WHICH ASPECT RAIO VECTORS WILL BE USED (THE 'J' COMPONENT)

F RATIO# >= 1! AND RATIO# <= 1.2 THEN
  J1 = 1
  J2 = 2
  LEFT# = 1!
  ELSEIF RATIO# > 1.2 AND RATIO# <= 1.4 THEN
     J1 = 2
     J2 = 3
     LEFT# = 1.2
  ELSEIF RATIO# > 1.4 AND RATIO# <= 1.6 THEN
     J1 = 3
     J2 = 4
     LEFT# = 1.4
  ELSEIF RATIO# > 1.6 AND RATIO# <= 1.8 THEN
     J1 = 4
     J2 = 5
     LEFT# = 1.6
  ELSEIF RATIO# > 1.8 AND RATIO# <= 2! THEN
     J1 = 5
     J2 = 6
     LEFT# = 1.8
  ELSEIF RATIO# > 2! AND RATIO# <= 2.2 THEN
     J1 = 6
     J2 = 7
     LEFT# = 2!
  ELSEIF RATIO# > 2.2 AND RATIO# <= 2.4 THEN
     J1 = 7
     J2 = 8
     LEFT# = 2.2
  ELSEIF RATIO# > 2.4 AND RATIO# <= 2.6 THEN
     J1 = 8
     J2 = 9
     LEFT# = 2.4
  ELSEIF RATIO# > 2.6 AND RATIO# <= 2.8 THEN
     J1 = 9
     J2 = 10
     LEFT# = 2.6
  ELSEIF RATIO# > 2.8 AND RATIO# <= 3! THEN
     J1 = 10
     J2 = 11
     LEFT# = 2.8
  ELSEIF RATIO# > 3! AND RATIO# <= 3.2 THEN
     J1 = 11
     J2 = 12
     LEFT# = 3!
  ELSEIF RATIO# > 3.2 AND RATIO# <= 3.4 THEN
     J1 = 12
     J2 = 13
     LEFT# = 3.2
  ELSEIF RATIO# > 3.4 AND RATIO# <= 3.6 THEN
     J1 = 13
     J2 = 14
     LEFT# = 3.4
```

```
  ELSEIF RATIO# > 3.6 AND RATIO# <= 3.8 THEN
     J1 = 14
     J2 = 15
     LEFT# = 3.6
  ELSEIF RATIO# > 3.8 AND RATIO# <= 4! THEN
     J1 = 15
     J2 = 16
     LEFT# = 3.8
  ELSEIF RATIO# > 4! AND RATIO# <= 4.2 THEN
     J1 = 16
     J2 = 17
     LEFT# = 4!
  ELSEIF RATIO# > 4.2 AND RATIO# <= 4.4 THEN
     J1 = 17
     J2 = 18
     LEFT# = 4.2
  ELSEIF RATIO# > 4.4 AND RATIO# <= 4.6 THEN
     J1 = 18
     J2 = 19
     LEFT# = 4.4
  ELSEIF RATIO# > 4.6 AND RATIO# <= 4.8 THEN
     J1 = 19
     J2 = 20
     LEFT# = 4.6
  ELSEIF RATIO# > 4.8 AND RATIO# <= 5! THEN
     J1 = 20
     J2 = 21
     LEFT# = 4.8
  ELSEIF RATIO# > 5! THEN
     LPRINT "WINDOW SIZE EXCEEDS PROGRAMS CAPABILITY"
ND IF

REA# = LENGTH# * LWIDTH#
FORCE# = F# * AREA#
ASS# = AREA# * THICK# * 161# / (386.4# * 1728#)

EM DIMENSIONALIZE THE DISPLACEMENTS, STRESSES AND, LOADS

OR I = 1 TO 31
   EDISP#(I, J1) = EDISP#(I, J1) * THICK#
   EDISP#(I, J2) = EDISP#(I, J2) * THICK#
   STRESS#(I, J1) = STRESS#(I, J1) * 10400000 * THICK# ^ 2 / AREA#
   STRESS#(I, J2) = STRESS#(I, J2) * 10400000 * THICK# ^ 2 / AREA#
EXT I

OR S = 1 TO 31
  LOAD#(S) = LOAD#(S) * 10400000# * THICK# ^ 4 / AREA#
EXT S

EM CALCULATE THE SPRING CONSTANTS FOR THE TWO ASPECT RATIOS

OR I = 1 TO 31
SPRING#(I, J1) = LOAD#(I) / EDISP#(I, J1)
SPRING#(I, J2) = LOAD#(I) / EDISP#(I, J2)
EXT I
```

```
:M    CALCULATE THE ACTUAL VALUES FOR EQUIVALENT MASS, EQUIVALENT FORCE,
:M    EQUIVALENT SPRING, AND EQUIVALENT DISPLACEMENTS

\CTORJ2# = (RATIO# - LEFT#) / .2#
\CTORJ1# = 1# - FACTORJ2#

)R E = 1 TO 31
:QMASS#(E) = (EMASS#(E, J1) * FACTORJ1# + EMASS#(E, J2) * FACTORJ2#)
:QDISP#(E) = (EDISP#(E, J1) * FACTORJ1# + EDISP#(E, J2) * FACTORJ2#)
:QFORCE#(E) = (EFORCE#(E, J1) * FACTORJ1# + EFORCE#(E, J2) * FACTORJ2#)
;PRING#(E) = (ESPRING#(E, J1) * FACTORJ1# + ESPRING#(E, J2) * FACTORJ2#)
:QSTRESS#(E) = (STRESS#(E, J1) * FACTORJ1# + STRESS#(E, J2) * FACTORJ2#)
:XT E

\CCEL# = PFORCE# * EQFORCE#(1) / (10# * MASS# * EQMASS#(1))

:M CALCULATE FOR EACH TIME STEP

)UNT# = -1#

:SIRE = DESIRE * 100
)R I = 1 TO DESIRE

)SUB 3000

M DETERMINE EQUIVALENT LOADINGS FROM GLASS DEFLECTION PRIOR TO LINEAR
M                         ACCELERATION METHOD

    TEST# = ABS(TDISP#)
    IF (TEST# <= EQDISP#(1)) THEN
       L = 1
       ELSEIF TEST# > EQDISP#(1) AND TEST# <= EQDISP#(2) THEN L = 2
       ELSEIF TEST# > EQDISP#(2) AND TEST# <= EQDISP#(3) THEN L = 3
       ELSEIF TEST# > EQDISP#(3) AND TEST# <= EQDISP#(4) THEN L = 4
       ELSEIF TEST# > EQDISP#(4) AND TEST# <= EQDISP#(5) THEN L = 5
       ELSEIF TEST# > EQDISP#(5) AND TEST# <= EQDISP#(6) THEN L = 6
       ELSEIF TEST# > EQDISP#(6) AND TEST# <= EQDISP#(7) THEN L = 7
       ELSEIF TEST# > EQDISP#(7) AND TEST# <= EQDISP#(8) THEN L = 8
       ELSEIF TEST# > EQDISP#(8) AND TEST# <= EQDISP#(9) THEN L = 9
       ELSEIF TEST# > EQDISP#(9) AND TEST# <= EQDISP#(10) THEN L = 10
       ELSEIF TEST# > EQDISP#(10) AND TEST# <= EQDISP#(11) THEN L = 11
       ELSEIF TEST# > EQDISP#(11) AND TEST# <= EQDISP#(12) THEN L = 12
       ELSEIF TEST# > EQDISP#(12) AND TEST# <= EQDISP#(13) THEN L = 13
       ELSEIF TEST# > EQDISP#(13) AND TEST# <= EQDISP#(14) THEN L = 14
       ELSEIF TEST# > EQDISP#(14) AND TEST# <= EQDISP#(15) THEN L = 15
       ELSEIF TEST# > EQDISP#(15) AND TEST# <= EQDISP#(16) THEN L = 16
       ELSEIF TEST# > EQDISP#(16) AND TEST# <= EQDISP#(17) THEN L = 17
       ELSEIF TEST# > EQDISP#(17) AND TEST# <= EQDISP#(18) THEN L = 18
       ELSEIF TEST# > EQDISP#(18) AND TEST# <= EQDISP#(19) THEN L = 19
       ELSEIF TEST# > EQDISP#(19) AND TEST# <= EQDISP#(20) THEN L = 20
       ELSEIF TEST# > EQDISP#(20) AND TEST# <= EQDISP#(21) THEN L = 21
       ELSEIF TEST# > EQDISP#(21) AND TEST# <= EQDISP#(22) THEN L = 22
       ELSEIF TEST# > EQDISP#(22) AND TEST# <= EQDISP#(23) THEN L = 23
       ELSEIF TEST# > EQDISP#(23) AND TEST# <= EQDISP#(24) THEN L = 24
       ELSEIF TEST# > EQDISP#(24) AND TEST# <= EQDISP#(25) THEN L = 25
       ELSEIF TEST# > EQDISP#(25) AND TEST# <= EQDISP#(26) THEN L = 26
       ELSEIF TEST# > EQDISP#(26) AND TEST# <= EQDISP#(27) THEN L = 27
```

```
        ELSEIF TEST# > EQDISP#(27) AND TEST# <= EQDISP#(28) THEN L = 28
        ELSEIF TEST# > EQDISP#(28) AND TEST# <= EQDISP#(29) THEN L = 29
        ELSEIF TEST# > EQDISP#(29) AND TEST# <= EQDISP#(30) THEN L = 30
     ELSE L = 31
     END IF

     QFORCE# = EQFORCE#(L) * FORCE#
     QMASS# = EQMASS#(L) * MASS#
     QSPRING# = EQSPRING#(L) * EQFORCE#(L)
     QSTRESS# = EQSTRESS#(L)

     IF L >= 2 THEN
        M = L - 1
        DISTANCE# = EQDISP#(L) - EQDISP#(M)
        DIST# = ABS(TDISP#) - EQDISP#(M)

     SLOPES# = (EQSPRING#(L) - EQSPRING#(M)) / DISTANCE#
     SLOPEM# = (EQMASS#(L) - EQMASS#(M)) / DISTANCE#
     SLOPEF# = (EQFORCE#(L) - EQFORCE#(M)) / DISTANCE#
     SLOPER# = (EQSTRESS#(L) - EQSTRESS#(M)) / DISTANCE#

     QSPRING# = (EQSPRING#(M) + (SLOPES# * DIST#)) * EQFORCE#(L)
     QMASS# = (EQMASS#(M) + (SLOPEM# * DIST#)) * MASS#
     QFORCE# = (EQFORCE#(M) + (SLOPEF# * DIST#)) * FORCE#
     QSTRESS# = (EQSTRESS#(M) + (SLOPER# * DIST#))

  END IF

  DAMPING# = DAMP# * 2# * SQR(QSPRING# * QMASS#)
  MASS1# = (A0# * TDISP#) + (A2# * TVEL#) + (A3# * TACCEL#)
  DAMP1# = (A1# * TDISP#) + (A4# * TVEL#) + (A5# * TACCEL#)

  R1# = QFORCE# + (QMASS# * MASS1#) + (DAMPING# * DAMP1#)
  K1# = (A0# * QMASS#) + (A1# * DAMPING#) + QSPRING#
  DISP1# = R1# / K1#
  DDISP# = DISP1# - TDISP#
  DVEL# = A1# * DDISP# - 3# * TVEL# - A5# * TACCEL#
  DACCEL# = A0# * DDISP# - A2# * TVEL# - 3# * TACCEL#
  TVEL# = TVEL# + DVEL#
  TACCEL# = TACCEL# + DACCEL#
  TDISP# = TDISP# + DDISP#

  IF (ABS(TDISP#) > MAX#) THEN
     MAX# = ABS(TDISP#)
     TIME# = T#
  END IF

  COUNT# = COUNT# + 1
  IF COUNT# = 10# THEN
     LPRINT USING "     #.####     ##.####        #####.###       #######.##
     COUNT# = 0
  END IF
  T# = T# + DELTAT#
XT I
```

```
PRINT " "
PRINT "      MAXIMUM DEFLECTION    TIME"
PRINT "       ---------------      ----"
PRINT USING "           ##.####          #.#### "; MAX#; TIME#
ND

EM FORCE CALCULATION SUBROUTINE

ORCE# = T# * PFORCE# * 1000#
F T# * 1000# >= 1# THEN
  FORCE# = PFORCE# * (1# - ((T# * 1000#) - 1) / (DURATION# - 1))
     IF FORCE# < 0 THEN
        FORCE# = 0
     END IF
ND IF
ETURN
ND

EM LOAD DATA

ATA 9.97, 12.81, 16.44, 21.12, 27.11, 34.81, 44.7, 57.4
ATA 73.7, 94.63, 121.51, 156.02, 200.34, 257.24, 330.3, 424.11
ATA 544.57, 699.24, 897.85, 1152.86, 1480.3, 1900.74, 2440.6, 3133.8
ATA 4023.87, 5166.75, 6634.24, 8518.54, 10938.02, 14044.69, 18033.74
```

APPENDIX B: This appendix presents a sample input file for use in the ABAQUS analysis. This sample corresponds to a 40" x 40", 0.71" thick window plate subjected to a peak blast load of 14.6 psi over a 26 millisecond duration.

The boundary conditions and glass properties specified are generic for all cases analyzed. In order to analyze any other plate or loading conditions either the geometry of the plate or the "*AMPLITUDE" input must be altered.

ABAQUS Finite Element Input Code

```
*HEADING
BLAST DEFLECTIONS OF 40" X 40" WINDOW PLATE
**
**NODE DEFINITIONS
**
*NODE
1, 0.0, 0.0, 0.0
         .
         .
         .
341, 40.0, 40.0, 0.0
**
**ELEMENT DEFINITIONS
**
*ELEMENT, TYPE=S8R5, ELSET=WINDOW
1, 1, 3, 35, 33, 2, 23, 34, 22
2, 3, 5, 37, 35, 4, 24, 36, 23
              .
              .
              .
99,  305, 307, 339, 337, 306, 319, 338, 318
100, 307, 309, 341, 339, 308, 320, 340, 319
**
** CREATE NODE AND ELEMENT SETS OF THE CORNER ELEMENT FOR
**         OUTPUT PURPOSES
**
*NSET, NSET=MIDDLE
262
*ELSET, ELSET=CORNER
73
**
** CREATE NODE SETS FOR THE EDGES OF THE PLATE FOR IMPLEMENTATION
**         OF THE BOUNDARY CONDITIONS: BOTTOM = BOTTOM EDGE
**         RTEDGE = RIGHT EDGE, LTEDGE = LEFT EDGE, & TOP = TOP
**
*NSET, NSET=BOTTOM, GENERATE
1, 18
*NSET, NSET=TOP, GENERATE
263, 279
*NSET, NSET=RTEDGE
29, 48, 58, 77, 87, 106, 116, 135, 145
164, 174, 193, 203, 222, 232, 251, 261, 280
```

```
*NSET, NSET=LTEDGE
20, 30, 49, 59, 78, 88, 107, 117, 136, 146
165, 175, 194, 204, 223, 233, 252
*SHELL SECTION, ELSET=WINDOW, MATERIAL=GLASS
.71
*MATERIAL, NAME=GLASS
*ELASTIC
10.4E6
**
** ENTER THE MATERIAL DENSITY - REQUIRED FOR DYNAMIC ANALYSIS
** GLASS= 161 LBS/CUBIC FOOT = 0.0002414 LBS/CUBIC INCH
**
*DENSITY
0.0002414
**
** IMPLEMENTATION OF BOUNDARY CONDITIONS. - ONLY ONE QUARTER OF
**      THE WINDOW PLATE IS MODELED/ANALYZED SO THESE BOUNDARY
**      CONDITIONS CONSIDER SYMMETRY.
**
*BOUNDARY
BOTTOM,   3
RTEDGE,   3
LTEDGE,   3
TOP,      3
1,      1, 3
21,     2, 3
**
** DESCRIBE THE BLAST LOAD: BASICALLY A TRIANGULAR LOADING FROM
**      A PEAK PRESSURE OF 14.6 PSI TO ZERO AT 26 MILLISECONDS.
**      ONE MILLISECOND IS USED TO DEVELOP THE BLAST PEAK
**
*AMPLITUDE, NAME=BLAST
0.0, 0.0, 0.001, 14.6, 0.026, 0.0, 1.0, 0.0
**
** BEGIN THE DYNAMIC ANALYSIS - THE FIRST, AND LARGEST, PEAK
**      OCCURS WITHIN THE FIRST 5 OR 6 MILLISECONDS (DISCOVERED
**      THRU TRIAL AND ERROR). SO, IN ORDER TO KEEP COMPUTER TIME
**      TO A MINIMUM, THE PROGRAM ONLY LOOKS AT THE FIRST 6
**      MILLISECONDS.
**
*STEP, NLGEOM, INC=60, CYCLE=20
*DYNAMIC, PTOL=1.0
0.0001, 1.0
*DLOAD, AMPLITUDE=BLAST
WINDOW, P, 1.0
**
```

```
** OUTPUT IS SPECIFIC TO THE CORNER QUANTITIES AND ONLY PRINTED
**      OUT EVERY 10 INCREMENTS - WHICH CORRESPONDS TO EVERY
**      MILLISECOND.
**
*EL FILE, ELSET=CORNER, FREQUENCY=10, POSITION=AVERAGED AT NODES
S
*EL PRINT, ELSET=CORNER, FREQUENCY=10, POSITION=AVERAGED AT NODES
S
*NODE FILE, NSET=MIDDLE, FREQUENCY=10
U
*NODE PRINT, NSET=MIDDLE, FREQUENCY=10
U
*END STEP
```

APPENDIX C: This appendix presents the output generated by WINBLAST. These tabular data show displacements, velocities, accelerations, and stresses as time progresses. At the end of each data set the maximum deflection and corresponding time is displayed.

The output included in this appendix is as shown on the following page.

WINDOW SIZE	THICKNESS	LOAD	DAMPING	PAGE NO.
26 x 26	0.71	14.6	0%	C-3
36 x 36	0.71	14.6	0%	C-4
40 x 40	0.71	14.6	0%	C-6
72 x 72	1.06	14.6	0%	C-8
72 x 72	1.06	30.0	0%	C-19
72 x 72	1.06	40.0	0%	C-21
72 x 72	1.06	50.0	0%	C-23
27 x 20	0.71	14.6	0%	C-25
32 x 20	0.71	14.6	0%	C-26
72 x 24	0.71	14.6	0%	C-27
72 x 24	0.71	75.0	0%	C-29
26 x 26	0.71	14.6	4%	C-31
26 x 26	0.355	7.3	4%	C-32
26 x 26	0.801	14.6	4%	C-34
36 x 36	0.71	14.6	4%	C-36
36 x 36	0.355	7.3	4%	C-38
36 x 36	0.809	14.6	4%	C-40
40 x 40	0.71	14.6	4%	C-42
40 x 40	0.355	7.3	4%	C-44
40 x 40	0.808	14.6	4%	C-46

INPUT DATA FOR WINBLAST PROGRAM:
****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 26 x 26
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.745	13524.6847	1.5471
0002	0.0002	2.765	26821.1238	11.2821
0003	0.0006	6.094	39663.4022	38.1314
0004	0.0015	10.675	51834.0620	90.7485
0005	0.0028	16.431	63127.0181	177.3507
0006	0.0048	23.265	73351.0474	305.5795
0007	0.0075	31.060	82333.0268	482.3718
0008	0.0110	39.685	89920.8650	713.8421
0009	0.0154	48.993	95986.0775	1005.1790
0010	0.0208	58.827	100425.9622	1360.5574
0011	0.0272	68.316	89086.9398	1781.9162
0012	0.0345	76.594	76239.4124	2263.8534
0013	0.0425	83.521	62100.9266	2797.8459
0014	0.0511	88.979	46910.8888	3374.4871
0015	0.0602	92.877	30926.5111	3983.6485
0016	0.0696	95.147	14418.4563	4614.6509
0017	0.0792	95.752	-2333.7456	5256.4452
0018	0.0887	94.682	-19046.4302	5897.7996
0019	0.0981	91.954	-35436.6026	6527.4898
0020	0.1071	87.614	-51226.7286	7134.4890
0021	0.1155	81.737	-66149.4349	7708.1545
0022	0.1234	74.422	-79952.0359	8238.4081
0023	0.1304	65.792	-92400.8129	8715.9068
0024	0.1365	55.994	-103284.9712	9132.2008
0025	0.1415	45.194	-112420.2101	9479.8766
0026	0.1455	33.574	-119651.8428	9752.6828
0027	0.1482	21.331	-124857.4165	9945.6357
0028	0.1497	8.673	-127948.7855	10055.1036
0029	0.1500	-4.186	-128873.6038	10078.8685
0030	0.1489	-17.028	-127616.2114	10016.1639
0031	0.1466	-29.636	-124197.8997	9867.6871
0032	0.1430	-41.797	-118676.5509	9635.5879
0033	0.1382	-53.304	-111145.6577	9323.4321
0034	0.1324	-63.963	-101732.7402	8936.1412
0035	0.1255	-73.593	-90597.1871	8479.9088
0036	0.1177	-82.031	-77927.5561	7962.0959
0037	0.1091	-89.135	-63938.3815	7391.1064
0038	0.0999	-94.783	-48866.5413	6776.2443
0039	0.0902	-98.880	-32967.2463	6127.5569

MAXIMUM DEFLECTION	TIME
0.1500	0.0029

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 36 x 36
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.746	13561.4822	0.8077
0002	0.0002	2.778	27060.6307	5.9006
0003	0.0006	6.154	40434.9819	20.0023
0004	0.0015	10.859	53622.8564	47.8035
0005	0.0028	16.870	66563.4347	93.9317
0006	0.0049	24.161	79197.0381	162.9301
0007	0.0077	32.698	91465.4031	259.2361
0008	0.0115	42.440	103311.9510	387.1614
0009	0.0162	53.344	114682.0483	550.8719
0010	0.0222	65.359	125523.2587	754.3682
0011	0.0293	77.724	121678.1728	1000.8667
0012	0.0377	89.676	117271.9355	1290.1351
0013	0.0472	101.160	112324.8674	1620.6500
0014	0.0579	112.123	106859.7832	1990.6970
0015	0.0697	122.515	100901.8865	2398.3791
0016	0.0824	132.288	94478.6539	2841.6261
0017	0.0961	141.396	87619.7077	3318.2036
0018	0.1107	149.799	80356.6799	3825.7234
0019	0.1260	157.455	72723.0658	4361.6549
0020	0.1421	164.332	64754.0698	4923.3360
0021	0.1589	170.396	56486.4432	5507.9864
0022	0.1762	175.620	47958.3142	6112.7194
0023	0.1940	179.980	39209.0127	6734.5559
0024	0.2121	183.456	30278.8884	7370.4381
0025	0.2306	186.032	21209.1248	8017.2430
0026	0.2493	187.695	12041.5498	8671.7976
0027	0.2681	188.438	2818.4419	9330.8929
0028	0.2870	188.258	-6417.6640	9991.2992
0029	0.3057	187.155	-15624.1731	10649.7805
0030	0.3244	185.115	-25465.5772	11312.8045
0031	0.3427	182.083	-35159.4654	11985.6554
0032	0.3608	178.087	-44738.5417	12646.0040
0033	0.3783	173.141	-54150.6947	13290.3435
0034	0.3954	167.264	-63343.5526	13915.2263
0035	0.4117	160.409	-73304.3477	14519.4160
0036	0.4274	152.636	-82096.4461	15097.7329
0037	0.4422	144.002	-90507.2031	15646.2086
0038	0.4562	134.549	-98483.3955	16161.7392
0039	0.4691	124.322	-105973.6534	16641.3780
0040	0.4810	113.372	-112928.9691	17082.3555
0041	0.4918	101.755	-119303.1972	17482.0964
0042	0.5013	89.442	-126728.6624	17837.7210
0043	0.5096	76.502	-131954.5388	18146.8361
0044	0.5166	63.076	-136452.3879	18407.7718
0045	0.5222	49.237	-140189.1576	18618.8529
0046	0.5265	35.064	-143137.3352	18778.6816
0047	0.5293	20.637	-145275.2915	18886.1484
0048	0.5306	6.037	-146587.5541	18940.4399

.0049	0.5305	-8.652	-147065.0046	18941.0447
.0050	0.5289	-23.348	-146704.9957	18887.7573
.0051	0.5258	-37.966	-145511.3859	18780.6789
.0052	0.5213	-52.423	-143494.4912	18620.2163
.0053	0.5153	-66.637	-140670.9545	18407.0786
.0054	0.5080	-80.530	-137063.5346	18142.2712
.0055	0.4992	-94.025	-132700.8199	17827.0876
.0056	0.4892	-106.977	-126122.1973	17462.7325
.0057	0.4778	-119.316	-120548.9487	17051.2998
.0058	0.4653	-131.067	-114356.6807	16595.3702
.0059	0.4517	-142.168	-107588.5167	16097.1960
.0060	0.4369	-152.566	-100290.8519	15559.2425
.0061	0.4212	-162.210	-92512.8621	14984.1714
.0062	0.4045	-171.055	-84305.9968	14374.8228
.0063	0.3870	-179.013	-74945.3452	13735.8022
.0064	0.3687	-186.075	-66245.3456	13070.5281
.0065	0.3498	-192.253	-57274.2764	12380.7121
.0066	0.3303	-197.523	-48083.9050	11669.6243
.0067	0.3103	-201.858	-38369.7468	10946.4478
.0068	0.2900	-205.254	-29518.1726	10234.0064
.0069	0.2693	-207.757	-20530.4675	9510.9114
.0070	0.2484	-209.357	-11448.0807	8780.3076
.0071	0.2275	-210.045	-2312.8981	8045.3738
.0072	0.2065	-209.819	6832.9512	7309.3094
.0073	0.1855	-208.680	15947.2884	6575.3186
.0074	0.1648	-206.632	24988.0805	5846.5961

AXIMUM DEFLECTION	TIME
0.5307	0.0048

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 40 x 40
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.746	13566.2176	0.6543
0002	0.0002	2.780	27091.5182	4.7812
0003	0.0006	6.162	40534.8350	16.2137
0004	0.0015	10.883	53855.4858	38.7699
0005	0.0029	16.928	67013.1600	76.2343
0006	0.0049	24.278	79968.0400	132.3462
0007	0.0077	32.913	92680.9220	210.7885
0008	0.0115	42.805	105113.3345	315.1764
0009	0.0164	53.925	117227.6546	449.0469
0010	0.0224	66.239	128987.2222	615.8474
0011	0.0296	79.004	126245.3065	818.4389
0012	0.0381	91.475	123121.3492	1056.9413
0013	0.0479	103.615	119624.8040	1330.4793
0014	0.0589	115.388	115766.2521	1638.0711
0015	0.0710	126.757	111557.3702	1978.6316
0016	0.0842	137.688	107010.8951	2350.9762
0017	0.0985	148.148	102140.5853	2753.8240
0018	0.1138	158.106	96961.1793	3185.8018
0019	0.1301	167.531	91488.3508	3645.4483
0020	0.1473	176.394	85738.6617	4131.2183
0021	0.1653	184.670	79729.5116	4641.4877
0022	0.1842	192.332	73479.0853	5174.5583
0023	0.2038	199.358	67006.2978	5728.6627
0024	0.2241	205.727	60330.7368	6301.9701
0025	0.2449	211.418	53472.6039	6892.5914
0026	0.2663	216.416	46452.6531	7498.5851
0027	0.2882	220.704	39292.1279	8117.9634
0028	0.3104	224.270	32012.6975	8748.6977
0029	0.3330	227.071	23966.2895	9406.7193
0030	0.3558	229.067	15919.1720	10081.9380
0031	0.3788	230.251	7756.8470	10762.1097
0032	0.4018	230.612	-1093.8003	11445.0870
0033	0.4249	230.078	-9599.3557	12131.1098
0034	0.4478	228.691	-18148.6475	12814.5282
0035	0.4706	226.448	-26710.1222	13492.7988
0036	0.4931	223.349	-35251.0837	14163.3737
0037	0.5152	219.302	-44987.7987	14822.3924
0038	0.5369	214.370	-53647.7592	15468.0374
0039	0.5581	208.577	-62186.6731	16098.0084
0040	0.5786	201.938	-70565.4825	16709.7661
0041	0.5984	194.470	-78744.7795	17300.8180
0042	0.6175	186.134	-88527.4430	17866.7881
0043	0.6356	176.881	-96482.4754	18402.8553
0044	0.6528	166.849	-104107.0769	18910.8190
0045	0.6690	156.072	-111358.9383	19388.4303
0046	0.6840	144.591	-118197.0377	19833.5486
0047	0.6979	132.448	-124582.0290	20244.1534
0048	0.7105	119.691	-130476.6230	20618.3564

.0049	0.7218	106.370	-135845.9565	20954.4121
.0050	0.7317	92.540	-140657.9435	21250.7281
.0051	0.7403	78.258	-144883.6041	21505.8750
.0052	0.7474	63.340	-151426.2989	21714.5941
.0053	0.7529	48.038	-154507.4530	21879.2240
.0054	0.7570	32.462	-156892.3735	21999.5143
.0055	0.7594	16.683	-158565.7154	22074.7594
.0056	0.7603	0.773	-159517.0549	22104.4576
.0057	0.7596	-15.196	-159741.0144	22088.3146
.0058	0.7573	-31.151	-159237.3281	22026.2451
.0059	0.7534	-47.019	-158010.8499	21918.3729
.0060	0.7479	-62.729	-156071.5010	21765.0298
.0061	0.7408	-78.210	-153434.1580	21566.7529
.0062	0.7322	-93.162	-147471.2222	21319.9332
.0063	0.7222	-107.726	-143714.4449	21029.0775
.0064	0.7107	-121.885	-139366.6713	20695.9032
.0065	0.6978	-135.581	-134456.3385	20321.6694
.0066	0.6836	-148.758	-129015.0754	19907.8019
.0067	0.6681	-161.367	-123077.3796	19455.8828
.0068	0.6514	-173.358	-116680.2698	18967.6414
.0069	0.6334	-184.689	-109862.9175	18444.9428
.0070	0.6144	-195.318	-102666.2647	17889.7766
.0071	0.5944	-205.105	-93601.5407	17300.0299
.0072	0.5734	-214.092	-86091.1128	16680.0410
.0073	0.5516	-222.315	-78331.2161	16034.2637
.0074	0.5290	-229.751	-70361.2523	15364.9948

MAXIMUM DEFLECTION	TIME
0.7603	0.0056

INPUT DATA FOR WINBLAST PROGRAM:
****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = 1.06 in.
WINDOW SIZE = 72 x 72
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
.0001	0.0000	0.500	9091.5741	0.2020
.0002	0.0001	1.864	18177.3249	1.4764
.0003	0.0004	4.135	27251.3936	5.0097
.0004	0.0010	7.313	36307.9488	11.9888
.0005	0.0019	11.396	45341.1699	23.5986
.0006	0.0033	16.381	54345.2516	41.0211
.0007	0.0052	22.264	63314.4073	65.4343
.0008	0.0078	29.042	72242.8728	98.0119
.0009	0.0111	36.711	81124.9100	139.9223
.0010	0.0152	45.265	89954.8107	192.3279
.0011	0.0201	54.227	89271.3390	256.2341
.0012	0.0260	63.118	88530.4953	331.8260
.0013	0.0327	71.931	87732.7558	419.0077
.0014	0.0404	80.662	86878.6332	517.6755
.0015	0.0489	89.305	85968.6763	627.7186
.0016	0.0582	97.854	85003.4700	749.0185
.0017	0.0684	106.304	83983.6346	881.4497
.0018	0.0795	114.649	82909.8255	1024.8796
.0019	0.0914	122.884	81782.7327	1179.1685
.0020	0.1041	131.004	80603.0808	1344.1695
.0021	0.1176	139.003	79371.6277	1519.7292
.0022	0.1319	146.877	78089.1649	1705.6869
.0023	0.1469	154.619	76756.5165	1901.8758
.0024	0.1628	162.226	75374.5392	2108.1221
.0025	0.1794	169.692	73944.1209	2324.2458
.0026	0.1967	177.013	72466.1810	2550.0602
.0027	0.2148	184.184	70941.6693	2785.3728
.0028	0.2335	191.200	69371.5656	3029.9848
.0029	0.2530	198.057	67756.8789	3283.6913
.0030	0.2732	204.750	66098.6469	3546.2818
.0031	0.2940	211.275	64397.9354	3817.5398
.0032	0.3154	217.628	62655.8373	4097.2436
.0033	0.3375	223.805	60873.4722	4385.1658
.0034	0.3602	229.802	59051.9856	4681.0737
.0035	0.3834	235.614	57192.5481	4984.7296
.0036	0.4073	241.239	55296.3547	5295.8908
.0037	0.4317	246.672	53364.6240	5614.3098
.0038	0.4566	251.911	51398.5976	5939.7343
.0039	0.4820	256.948	49257.1156	6276.1577
.0040	0.5080	261.765	47076.7247	6629.5515
.0041	0.5344	266.362	44851.7985	6989.4010
.0042	0.5612	270.734	42583.3266	7355.4030
.0043	0.5885	274.877	40272.3629	7727.2485
.0044	0.6162	278.772	37697.7194	8105.9192
.0045	0.6443	282.419	35249.8137	8490.3178
.0046	0.6727	285.820	32759.4333	8879.5848
.0047	0.7014	288.970	30227.9160	9273.3791
.0048	0.7305	291.864	27656.6872	9671.3540

0.0049	0.7598	294.477	24672.4796	10072.5917
0.0050	0.7894	296.809	21948.9745	10476.8870
0.0051	0.8191	298.866	19186.2418	10884.2231
0.0052	0.8491	300.645	16386.1612	11294.2225
0.0053	0.8793	302.142	13550.7252	11706.5023
0.0054	0.9095	303.354	10682.0391	12120.6753
0.0055	0.9399	304.226	7132.5994	12532.3389
0.0056	0.9704	304.787	4091.4009	12944.4562
0.0057	1.0009	305.043	1019.9030	13357.1683
0.0058	1.0314	304.990	-2079.0754	13770.0599
0.0059	1.0619	304.626	-5202.5834	14182.7118
0.0060	1.0923	303.949	-8347.5415	14594.7018
0.0061	1.1226	302.915	-12465.0538	15001.6535
0.0062	1.1529	301.502	-15781.9474	15402.3681
0.0063	1.1829	299.758	-19113.1547	15801.0352
0.0064	1.2128	297.679	-22454.6723	16197.2134
0.0065	1.2425	295.267	-25802.3680	16590.4602
0.0066	1.2718	292.519	-29151.9886	16980.3320
0.0067	1.3009	289.436	-32499.1687	17366.3848
0.0068	1.3297	286.012	-37235.1460	17748.7770
0.0069	1.3581	282.115	-40715.5299	18139.7447
0.0070	1.3861	277.870	-44179.9467	18525.1650
0.0071	1.4137	273.279	-47623.0655	18904.5613
0.0072	1.4408	268.346	-51039.4807	19277.4601
0.0073	1.4674	263.073	-54423.7258	19643.3916
0.0074	1.4934	257.463	-57770.2882	20001.8902
0.0075	1.5188	251.520	-61073.6242	20352.4956
0.0076	1.5437	245.250	-64328.1746	20694.7531
0.0077	1.5679	238.656	-67528.3804	21028.2149
0.0078	1.5914	231.569	-72821.0099	21370.4424
0.0079	1.6142	224.124	-76055.9490	21706.3942
0.0080	1.6362	216.360	-79214.4705	22031.2175
0.0081	1.6574	208.284	-82290.4148	22344.4472
0.0082	1.6778	199.905	-85277.7185	22645.6300
0.0083	1.6974	191.232	-88170.4349	22934.3257
0.0084	1.7161	182.274	-90962.7540	23210.1078
0.0085	1.7339	173.043	-93649.0221	23472.5646
0.0086	1.7507	163.548	-96223.7618	23721.2998
0.0087	1.7666	153.802	-98681.6905	23955.9334
0.0088	1.7814	143.816	-101017.7393	24176.1026
0.0089	1.7953	133.603	-103227.0708	24381.4623
0.0090	1.8082	123.175	-105305.0962	24571.6860
0.0091	1.8199	112.546	-107247.4918	24746.4664
0.0092	1.8307	101.730	-109050.2150	24905.5162
0.0093	1.8403	90.697	-113629.0580	25049.8356
0.0094	1.8488	79.254	-115207.5934	25186.1992
0.0095	1.8561	67.661	-116623.2051	25304.3493
0.0096	1.8623	55.935	-117872.7712	25404.0593
0.0097	1.8673	44.092	-118953.5723	25485.1286
0.0098	1.8711	32.150	-119863.3038	25547.3835
0.0099	1.8737	20.125	-120600.0842	25590.6773
0.0100	1.8751	8.036	-121162.4638	25614.8905
0.0101	1.8753	-4.101	-121549.4304	25619.9315
0.0102	1.8743	-16.268	-121760.4145	25605.7362
0.0103	1.8721	-28.447	-121795.2914	25572.2683
0.0104	1.8686	-40.621	-121654.3830	25519.5196
0.0105	1.8640	-52.772	-121338.4570	25447.5096
0.0106	1.8581	-64.883	-120848.7244	25356.2855
0.0107	1.8510	-76.936	-120186.8361	25245.9221
0.0108	1.8427	-88.915	-119354.8766	25116.5214

0.0109	1.8332	-100.672	-115480.0560	24972.8321
0.0110	1.8226	-112.167	-114402.8445	24818.1259
0.0111	1.8108	-123.547	-113176.5863	24646.5931
0.0112	1.7979	-134.797	-111804.5064	24458.4119
0.0113	1.7838	-145.903	-110290.1577	24253.7817
0.0114	1.7687	-156.851	-108637.4098	24032.9229
0.0115	1.7525	-167.626	-106850.4352	23796.0762
0.0116	1.7352	-178.216	-104933.6957	23543.5024
0.0117	1.7168	-188.609	-102891.9270	23275.4812
0.0118	1.6975	-198.791	-100730.1227	22992.3106
0.0119	1.6771	-208.751	-98453.5178	22694.3066
0.0120	1.6557	-218.478	-96067.5712	22381.8021
0.0121	1.6334	-227.961	-93577.9473	22055.1459
0.0122	1.6101	-237.190	-90990.4972	21714.7025
0.0123	1.5860	-246.156	-88311.2399	21360.8504
0.0124	1.5609	-254.800	-83578.8436	21000.2868
0.0125	1.5350	-263.025	-80911.9728	20645.5593
0.0126	1.5083	-270.980	-78175.7920	20279.6756
0.0127	1.4808	-278.658	-75375.9196	19903.0108
0.0128	1.4526	-286.053	-72518.0368	19515.9487
0.0129	1.4236	-293.160	-69607.8707	19118.8813
0.0130	1.3940	-299.973	-66651.1783	18712.2078
0.0131	1.3636	-306.489	-63653.7297	18296.3339
0.0132	1.3327	-312.703	-60621.2924	17871.6709
0.0133	1.3011	-318.526	-56287.1321	17449.1410
0.0134	1.2690	-324.009	-53364.5838	17024.0872
0.0135	1.2363	-329.198	-50422.4173	16591.9228
0.0136	1.2032	-334.093	-47465.5384	16153.0373
0.0137	1.1695	-338.691	-44498.7916	15707.8225
0.0138	1.1354	-342.992	-41526.9486	15256.6713
0.0139	1.1009	-346.992	-37673.8766	14799.6114
0.0140	1.0660	-350.618	-34854.1731	14327.9517
0.0141	1.0308	-353.963	-32038.6214	13851.5359
0.0142	0.9953	-357.026	-29231.0407	13370.7454
0.0143	0.9594	-359.809	-26435.1522	12885.9603
0.0144	0.9233	-362.314	-23654.5727	12397.5592
0.0145	0.8870	-364.513	-20407.7693	11902.9923
0.0146	0.8504	-366.422	-17784.5056	11403.0861
0.0147	0.8137	-368.070	-15180.4699	10900.7100
0.0148	0.7768	-369.459	-12598.4337	10396.2207
0.0149	0.7398	-370.591	-10041.0638	9889.9719
0.0150	0.7027	-371.444	-7259.7676	9381.3029
0.0151	0.6655	-372.048	-4839.5295	8871.4627
0.0152	0.6283	-372.412	-2444.7585	8360.9253
0.0153	0.5910	-372.538	-77.4763	7850.0196
0.0154	0.5538	-372.414	2384.7116	7341.4677
0.0155	0.5166	-372.063	4636.4221	6833.2802
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0.0157	0.4423	-370.689	9036.8814	5833.8430
0.0158	0.4053	-369.684	11052.4775	5349.4631
0.0159	0.3684	-368.478	13060.9706	4866.5025
0.0160	0.3316	-367.072	15061.0698	4385.2241
0.0161	0.2949	-365.466	17051.4896	3905.8895
0.0162	0.2585	-363.662	19030.9511	3428.7593
0.0163	0.2222	-361.661	20998.1819	2954.0925
0.0164	0.1862	-359.463	22951.9178	2482.1466
0.0165	0.1503	-357.071	24890.9032	2013.1773
0.0166	0.1148	-354.485	26813.8920	1547.4385
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0.0168	0.0444	-348.742	30606.9475	626.6569

0.0169	0.0097	-345.588	32474.5764	172.1107
0.0170	-0.0247	-342.248	34321.3350	-278.2121
0.0171	-0.0587	-338.724	36146.0362	-724.0697
0.0172	-0.0924	-335.019	37947.5076	-1165.2231
0.0173	-0.1257	-331.136	39724.5912	-1601.4365
0.0174	-0.1587	-327.075	41476.1451	-2032.4770
0.0175	-0.1912	-322.841	43201.0435	-2458.1153
0.0176	-0.2232	-318.436	44898.1779	-2878.1252
0.0177	-0.2548	-313.863	46566.4576	-3292.2845
0.0178	-0.2860	-309.124	48204.8106	-3700.3746
0.0179	-0.3167	-304.223	49812.1837	-4102.1808
0.0180	-0.3468	-299.162	51387.5441	-4497.4924
0.0181	-0.3765	-293.946	52929.8793	-4886.1030
0.0182	-0.4056	-288.578	54438.1981	-5267.8103
0.0183	-0.4342	-283.060	55911.5311	-5642.4167
0.0184	-0.4622	-277.397	57348.9315	-6009.7290
0.0185	-0.4897	-271.584	58912.9840	-6378.0595
0.0186	-0.5165	-265.618	60397.5410	-6745.5372
0.0187	-0.5428	-259.505	61852.8218	-7104.7909
0.0188	-0.5684	-253.249	63276.9452	-7455.6215
0.0189	-0.5934	-246.851	64668.0508	-7797.8343
0.0190	-0.6178	-240.299	66242.0326	-8132.6624
0.0191	-0.6415	-233.607	67599.6255	-8458.6062
0.0192	-0.6645	-226.780	68919.7049	-8775.2967
0.0193	-0.6868	-219.824	70200.2717	-9082.5523
0.0194	-0.7085	-212.742	71439.3670	-9380.1968
0.0195	-0.7294	-205.538	72635.0763	-9668.0597
0.0196	-0.7496	-198.201	74134.8009	-9945.7056
0.0197	-0.7690	-190.730	75284.5362	-10212.8649
0.0198	-0.7877	-183.146	76385.0739	-10469.7375
0.0199	-0.8056	-175.454	77434.4355	-10716.1722
0.0200	-0.8228	-167.661	78430.7136	-10952.0247
0.0201	-0.8392	-159.770	79372.0754	-11177.1580
0.0202	-0.8547	-151.788	80256.7671	-11391.4424
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0.0204	-0.8835	-135.574	81849.5421	-11786.9854
0.0205	-0.8966	-127.353	82554.5458	-11968.0244
0.0206	-0.9090	-119.065	83196.7269	-12137.7758
0.0207	-0.9204	-110.673	84356.5510	-12294.7719
0.0208	-0.9311	-102.209	84903.1218	-12439.9954
0.0209	-0.9409	-93.695	85380.5634	-12573.7348
0.0210	-0.9498	-85.136	85787.6959	-12695.9244
0.0211	-0.9579	-76.540	86123.4623	-12806.5083
0.0212	-0.9651	-67.913	86386.9303	-12905.4399
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0.0215	-0.9816	-41.928	86736.1348	-13132.0046
0.0216	-0.9854	-33.256	86703.6483	-13184.0604
0.0217	-0.9883	-24.590	86596.1350	-13224.3804
0.0218	-0.9903	-15.939	86413.4429	-13252.9782
0.0219	-0.9915	-7.310	86155.5523	-13269.8776
0.0220	-0.9918	1.290	85822.5751	-13275.1124
0.0221	-0.9912	9.852	85414.7546	-13268.7266
0.0222	-0.9898	18.370	84932.4638	-13250.7746
0.0223	-0.9875	26.836	84376.2049	-13221.3205
0.0224	-0.9844	35.243	83746.6070	-13180.4385
0.0225	-0.9805	43.583	83044.4241	-13128.2131
0.0226	-0.9757	51.849	82270.5331	-13064.7381
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0.0228	-0.9637	68.132	80511.7326	-12904.4644

0229	-0.9565	76.135	79529.1653	-12807.9017
0230	-0.9485	84.036	78479.5680	-12700.5616
0231	-0.9397	91.829	77364.3859	-12582.5850
0232	-0.9301	99.507	76185.1668	-12454.1222
0233	-0.9198	107.063	74943.5569	-12315.3317
0234	-0.9087	114.490	73090.7579	-12166.3251
0235	-0.8969	121.734	71766.8241	-12005.6667
0236	-0.8844	128.842	70387.9193	-11835.1691
0237	-0.8711	135.810	68955.8163	-11655.0203
0238	-0.8572	142.631	67472.3528	-11465.4157
0239	-0.8426	149.302	65939.4279	-11266.5575
0240	-0.8274	155.818	64358.9967	-11058.6548
0241	-0.8115	162.173	62733.0659	-10841.9233
0242	-0.7949	168.363	61063.6891	-10616.5847
0243	-0.7778	174.384	59352.9620	-10382.8670
0244	-0.7601	180.232	57603.0174	-10141.0037
0245	-0.7417	185.903	55816.0204	-9891.2336
0246	-0.7229	191.371	53699.1049	-9633.3637
0247	-0.7035	196.650	51887.6482	-9367.9580
0248	-0.6836	201.747	50045.2551	-9095.4105
0249	-0.6631	206.659	48173.9387	-8815.9736
0250	-0.6422	211.381	46275.7223	-8529.9034
0251	-0.6209	215.913	44352.6354	-8237.4601
0252	-0.5991	220.251	42406.7101	-7938.9070
0253	-0.5768	224.382	40278.7353	-7635.4811
0254	-0.5542	228.313	38325.9995	-7327.0266
0255	-0.5312	232.047	36355.0851	-7013.3139
0256	-0.5078	235.583	34367.8293	-6694.6119
0257	-0.4841	238.920	32366.0589	-6371.1914
0258	-0.4600	242.053	30292.0577	-6048.7916
0259	-0.4357	244.986	28363.1290	-5730.6158
0260	-0.4110	247.725	26415.9723	-5408.7048
0261	-0.3861	250.287	24815.5142	-5083.3073
0262	-0.3610	252.688	23199.1079	-4754.6429
0263	-0.3356	254.926	21567.7923	-4422.9228
0264	-0.3100	257.001	19922.6158	-4088.3602
0265	-0.2842	258.910	18264.6356	-3751.1702
0266	-0.2582	260.653	16594.9172	-3411.5694
0267	-0.2321	262.229	14914.5338	-3069.7761
0268	-0.2058	263.636	13224.5654	-2726.0100
0269	-0.1793	264.874	11526.0978	-2380.4919
0270	-0.1528	265.941	9820.2229	-2033.4439
0271	-0.1262	266.837	8108.0367	-1685.0892
0272	-0.0994	267.562	6390.6398	-1335.6514
0273	-0.0726	268.115	4669.1358	-985.3553
0274	-0.0458	268.496	2944.6311	-634.4259
0275	-0.0190	268.704	1218.2340	-283.0889
0276	0.0079	268.740	-508.9461	68.4302
0277	0.0348	268.603	-2235.7990	419.9052
0278	0.0616	268.293	-3961.2151	771.1104
0279	0.0884	267.810	-5684.0855	1121.8200
0280	0.1152	267.156	-7403.3028	1471.8087
0281	0.1419	266.330	-9117.7623	1820.8515
0282	0.1685	265.333	-10826.3620	2168.7241
0283	0.1949	264.165	-12528.0040	2515.2029
0284	0.2213	262.827	-14221.5947	2860.0652
0285	0.2475	261.321	-15906.0455	3203.0895
0286	0.2735	259.646	-17580.2740	3544.0552
0287	0.2994	257.805	-19243.2043	3882.7433
0288	0.3251	255.798	-20893.7675	4218.9361

0289	0.3506	253.627	-22530.9029	4552.4175
0290	0.3758	251.292	-24153.5584	4882.9732
0291	0.4008	248.797	-25760.6911	5210.3908
0292	0.4256	246.141	-27351.2683	5534.4598
0293	0.4500	243.327	-28924.2676	5854.9719
0294	0.4742	240.357	-30478.6782	6171.7213
0295	0.4981	237.217	-32223.6323	6498.0055
0296	0.5217	233.913	-33855.5465	6820.0261
0297	0.5449	230.446	-35473.3457	7137.4478
0298	0.5677	226.819	-37075.4642	7450.0494
0299	0.5902	223.032	-38660.3306	7757.6121
0300	0.6123	219.072	-40437.4711	8060.9997
0301	0.6341	214.949	-42019.2986	8359.2406
0302	0.6553	210.669	-43580.0831	8651.7398
0303	0.6762	206.234	-45118.0815	8938.2829
0304	0.6966	201.647	-46631.5558	9218.6588
0305	0.7165	196.909	-48118.7762	9492.6594
0306	0.7360	192.024	-49578.0244	9760.0805
0307	0.7549	186.968	-51370.1698	10020.2728
0308	0.7733	181.759	-52813.3545	10273.3013
0309	0.7912	176.407	-54223.4536	10519.1224
0310	0.8086	170.915	-55598.6091	10757.5424
0311	0.8254	165.288	-56936.9926	10988.3729
0312	0.8417	159.529	-58236.8089	11211.4301
0313	0.8573	153.642	-59496.2998	11426.5356
0314	0.8724	147.631	-60713.7483	11633.5166
0315	0.8869	141.501	-61887.4821	11832.2058
0316	0.9007	135.255	-63015.8775	12022.4420
0317	0.9139	128.891	-64658.2405	12203.7135
0318	0.9265	122.371	-65732.1335	12374.6536
0319	0.9384	115.746	-66754.2542	12536.7114
0320	0.9496	109.022	-67723.0134	12689.7479
0321	0.9602	102.203	-68636.8965	12833.6313
0322	0.9700	95.296	-69494.4675	12968.2370
0323	0.9792	88.306	-70294.3725	13093.4483
0324	0.9877	81.240	-71035.3431	13209.1562
0325	0.9955	74.101	-71716.1995	13315.2595
0326	1.0025	66.898	-72335.8537	13411.6653
0327	1.0089	59.636	-72893.3119	13498.2888
0328	1.0144	52.322	-73387.6774	13575.0539
0329	1.0193	44.961	-73818.1523	13641.8927
0330	1.0234	37.560	-74184.0403	13698.7461
0331	1.0268	30.126	-74484.7478	13745.5637
0332	1.0295	22.666	-74719.7859	13782.3039
0333	1.0314	15.185	-74888.7713	13808.9341
0334	1.0325	7.690	-74991.4276	13825.4304
0335	1.0329	0.189	-75027.5857	13831.7781
0336	1.0325	-7.313	-74997.1845	13827.9714
0337	1.0314	-14.809	-74900.2708	13814.0134
0338	1.0296	-22.291	-74736.9995	13789.9165
0339	1.0270	-29.754	-74507.6330	13755.7017
0340	1.0236	-37.190	-74212.5405	13711.3993
0341	1.0195	-44.594	-73852.1973	13657.0483
0342	1.0147	-51.959	-73427.1831	13592.6967
0343	1.0091	-59.277	-72938.1813	13518.4009
0344	1.0029	-66.544	-72385.9765	13434.2264
0345	0.9958	-73.753	-71771.4529	13340.2470
0346	0.9881	-80.896	-71095.5919	13236.5452
0347	0.9797	-87.970	-70359.4699	13123.2114
0348	0.9705	-94.966	-69564.2553	13000.3445

0.0349	0.9607	-101.881	-68711.2056	12868.0514
0.0350	0.9501	-108.707	-67801.6644	12726.4468
0.0351	0.9389	-115.439	-66837.0580	12575.6529
0.0352	0.9271	-122.072	-65818.8916	12415.7996
0.0353	0.9145	-128.601	-64748.7462	12247.0239
0.0354	0.9013	-134.991	-63100.7615	12068.3510
0.0355	0.8875	-141.245	-61975.2660	11880.1815
0.0356	0.8731	-147.384	-60804.2423	11683.5156
0.0357	0.8581	-153.404	-59589.3094	11478.5129
0.0358	0.8424	-159.301	-58332.1352	11265.3390
0.0359	0.8262	-165.069	-57034.4332	11044.1654
0.0360	0.8094	-170.706	-55697.9582	10815.1691
0.0361	0.7921	-176.208	-54324.5029	10578.5325
0.0362	0.7742	-181.570	-52915.8938	10334.4431
0.0363	0.7558	-186.790	-51473.9874	10083.0930
0.0364	0.7368	-191.862	-49673.6367	9824.6699
0.0365	0.7174	-196.757	-48215.2226	9558.8054
0.0366	0.6975	-201.504	-46728.6599	9286.3075
0.0367	0.6771	-206.102	-45215.6674	9007.3800
0.0368	0.6563	-210.547	-43677.9760	8722.2300
0.0369	0.6350	-214.836	-42117.3250	8431.0679
0.0370	0.6133	-218.969	-40535.4594	8134.1077
0.0371	0.5912	-222.942	-38751.0719	7831.5842
0.0372	0.5687	-226.738	-37165.9796	7525.1731
0.0373	0.5459	-230.375	-35563.4972	7213.6670
0.0374	0.5226	-233.850	-33945.1988	6897.2847
0.0375	0.4991	-237.163	-32312.6530	6576.2468
0.0376	0.4752	-240.312	-30667.4209	6250.7758
0.0377	0.4510	-243.292	-28988.3366	5931.6644
0.0378	0.4266	-246.112	-27415.5428	5611.9311
0.0379	0.4018	-248.774	-25825.1299	5288.5911
0.0380	0.3768	-251.277	-24218.1200	4961.8523
0.0381	0.3516	-253.617	-22595.5458	4631.9247
0.0382	0.3261	-255.795	-20958.4502	4299.0203
0.0383	0.3004	-257.809	-19307.8852	3963.3531
0.0384	0.2745	-259.656	-17644.9116	3625.1387
0.0385	0.2485	-261.337	-15970.5982	3284.5946
0.0386	0.2223	-262.850	-14286.0210	2941.9395
0.0387	0.1959	-264.194	-12592.2626	2597.3938
0.0388	0.1694	-265.368	-10890.4115	2251.1788
0.0389	0.1429	-266.372	-9181.5615	1903.5170
0.0390	0.1162	-267.204	-7466.8108	1554.6319
0.0391	0.0894	-267.865	-5747.2614	1204.7477
0.0392	0.0626	-268.354	-4024.0184	854.0892
0.0393	0.0358	-268.670	-2298.1893	502.8819
0.0394	0.0089	-268.813	-570.8832	151.3513
0.0395	-0.0180	-268.784	1156.7897	-200.2765
0.0396	-0.0449	-268.582	2883.7193	-551.7756
0.0397	-0.0717	-268.207	4608.7955	-902.9201
0.0398	-0.0985	-267.660	6330.9098	-1253.4843
0.0399	-0.1252	-266.941	8048.9555	-1603.2430
0.0400	-0.1519	-266.051	9761.8283	-1951.9713
0.0401	-0.1784	-264.989	11468.4275	-2299.4451
0.0402	-0.2049	-263.757	13167.6563	-2645.4411
0.0403	-0.2312	-262.356	14858.4226	-2989.7370
0.0404	-0.2573	-260.786	16539.6399	-3332.1115
0.0405	-0.2833	-259.048	18210.2277	-3672.3445
0.0406	-0.3091	-257.144	19869.1123	-4010.2175
0.0407	-0.3348	-255.075	21515.2277	-4345.5132
0.0408	-0.3602	-252.842	23147.5158	-4678.0161

0.0409	-0.3853	-250.446	24764.9278	-5007.5127
0.0410	-0.4102	-247.889	26366.4241	-5333.7910
0.0411	-0.4349	-245.173	27950.9755	-5656.6415
0.0412	-0.4593	-242.300	29517.5637	-5975.8567
0.0413	-0.4834	-239.266	31206.4108	-6296.3226
0.0414	-0.5071	-236.063	32846.8717	-6621.1958
0.0415	-0.5306	-232.697	34474.1902	-6941.6078
0.0416	-0.5537	-229.169	36086.8045	-7257.3362
0.0417	-0.5764	-225.480	37683.1457	-7568.1609
0.0418	-0.5987	-221.630	39450.9328	-7874.0496
0.0419	-0.6207	-217.605	41045.5461	-8175.8526
0.0420	-0.6423	-213.422	42620.2015	-8472.0476
0.0421	-0.6634	-209.082	44173.1537	-8762.4185
0.0422	-0.6841	-204.588	45702.6605	-9046.7518
0.0423	-0.7043	-199.942	47206.9856	-9324.8376
0.0424	-0.7241	-195.147	48684.4026	-9596.4691
0.0425	-0.7433	-190.201	50468.2111	-9861.3684
0.0426	-0.7621	-185.081	51931.6101	-10118.8704
0.0427	-0.7803	-179.816	53363.0863	-10369.2858
0.0428	-0.7980	-174.410	54760.7648	-10612.4183
0.0429	-0.8152	-168.865	56122.7974	-10848.0761
0.0430	-0.8318	-163.186	57447.3667	-11076.0724
0.0431	-0.8478	-157.377	58732.6902	-11296.2254
0.0432	-0.8633	-151.441	59977.0239	-11508.3586
0.0433	-0.8781	-145.383	61178.6664	-11712.3014
0.0434	-0.8924	-139.207	62335.9623	-11907.8885
0.0435	-0.9060	-132.917	63447.3064	-12094.9611
0.0436	-0.9189	-126.488	65088.3563	-12272.2448
0.0437	-0.9313	-119.926	66143.3597	-12439.9092
0.0438	-0.9429	-113.261	67145.9644	-12598.6355
0.0439	-0.9539	-106.498	68094.6081	-12748.2872
0.0440	-0.9642	-99.644	68987.8044	-12888.7351
0.0441	-0.9738	-92.703	69824.1473	-13019.8577
0.0442	-0.9828	-85.681	70602.3140	-13141.5409
0.0443	-0.9910	-78.584	71321.0683	-13253.6787
0.0444	-0.9985	-71.419	71979.2642	-13356.1730
0.0445	-1.0052	-64.191	72575.8482	-13448.9338
0.0446	-1.0113	-56.906	73109.8622	-13531.8797
0.0447	-1.0166	-49.571	73580.4461	-13604.9374
0.0448	-1.0212	-42.192	73986.8396	-13668.0424
0.0449	-1.0251	-34.775	74328.3846	-13721.1389
0.0450	-1.0282	-27.328	74604.5265	-13764.1797
0.0451	-1.0305	-19.857	74814.8156	-13797.1266
0.0452	-1.0321	-12.368	74958.9088	-13819.9502
0.0453	-1.0330	-4.867	75036.5697	-13832.6302
0.0454	-1.0331	2.638	75047.6699	-13835.1550
0.0455	-1.0325	10.140	74992.1888	-13827.5224
0.0456	-1.0311	17.634	74870.2141	-13809.7389
0.0457	-1.0290	25.112	74681.9414	-13781.8202
0.0458	-1.0261	32.568	74427.6734	-13743.7908
0.0459	-1.0224	39.995	74107.8196	-13695.6842
0.0460	-1.0181	47.387	73722.8952	-13637.5428
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.0469	-0.9462	111.288	67465.5042	-12673.9880
.0470	-0.9348	117.986	66480.1593	-12519.7187
.0471	-0.9226	124.582	65441.8213	-12356.4381
.0472	-0.9099	131.072	64352.0995	-12184.2858
.0473	-0.8964	137.400	62700.7097	-12001.5790
.0474	-0.8824	143.614	61557.4614	-11810.1341
.0475	-0.8677	149.710	60369.2737	-11610.2496
.0476	-0.8524	155.686	59137.7850	-11402.0875
.0477	-0.8366	161.537	57864.6817	-11185.8159
.0478	-0.8201	167.258	56551.6941	-10961.6083
.0479	-0.8031	172.846	55200.5927	-10729.6439
0480	-0.7856	178.297	53813.1841	-10490.1071
0481	-0.7675	183.607	52391.3076	-10243.1871
0482	-0.7489	188.774	50936.8305	-9989.0782
0483	-0.7297	193.782	49140.9845	-9727.7494
0484	-0.7101	198.623	47671.2464	-9459.2804
0485	-0.6900	203.316	46173.9991	-9184.2526
0486	-0.6695	207.857	44650.9670	-8902.8710
0487	-0.6485	212.245	43103.8854	-8615.3442
0488	-0.6270	216.477	41534.4970	-8321.8841
0489	-0.6052	220.551	39944.5486	-8022.7056
0490	-0.5829	224.459	38165.4761	-7718.5920
0491	-0.5603	228.196	36573.1113	-7410.1418
0492	-0.5373	231.773	34963.9481	-7096.6776
0493	-0.5139	235.189	33339.5595	-6778.4188
0494	-0.4902	238.441	31701.5122	-6455.5870
0495	-0.4662	241.527	29965.5512	-6130.3208
0496	-0.4419	244.446	28403.7837	-5812.8444
0497	-0.4174	247.207	26823.7619	-5491.6323
0498	-0.3925	249.810	25226.5013	-5166.8909
0499	-0.3674	252.252	23613.0285	-4838.8289
0500	-0.3421	254.532	21984.3802	-4507.6571
0501	-0.3165	256.648	20341.6033	-4173.5884
0502	-0.2907	258.600	18685.7534	-3836.8374
0503	-0.2648	260.385	17017.8948	-3497.6207
0504	-0.2387	262.003	15339.0993	-3156.1561
0505	-0.2124	263.453	13650.4459	-2812.6631
0506	-0.1860	264.733	11953.0197	-2467.3626
0507	-0.1594	265.843	10247.9117	-2120.4763
0508	-0.1328	266.782	8536.2176	-1772.2273
0509	-0.1061	267.550	6819.0376	-1422.8393
0510	-0.0793	268.146	5097.4752	-1072.5369
0511	-0.0525	268.569	3372.6369	-721.5452
0512	-0.0256	268.820	1645.6310	-370.0899
0513	0.0013	268.899	-82.4325	-18.3966
0514	0.0282	268.804	-1810.4430	333.3085
0515	0.0550	268.537	-3537.2899	684.7993
0516	0.0819	268.097	-5261.8636	1035.8501
0517	0.1087	267.484	-6983.0556	1386.2351
0518	0.1354	266.700	-8699.7599	1735.7293
0519	0.1620	265.745	-10410.8730	2084.1079
0520	0.1885	264.618	-12115.2954	2431.1472
0521	0.2149	263.322	-13811.9317	2776.6240
0522	0.2412	261.856	-15499.6915	3120.3164
0523	0.2673	260.222	-17177.4901	3462.0035
0524	0.2932	258.421	-18844.2493	3801.4656
0525	0.3189	256.454	-20498.8978	4138.4847
0526	0.3445	254.322	-22140.3723	4472.8441
0527	0.3698	252.026	-23767.6179	4804.3289
0528	0.3949	249.569	-25379.5888	5132.7261

.0529	0.4197	246.951	-26975.2490	5457.8247
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.0531	0.4685	241.241	-30113.5465	6097.2924
.0532	0.4925	238.141	-31837.7460	6421.5650
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.0535	0.5625	227.857	-36703.5538	7377.6132
.0536	0.5851	224.107	-38293.8398	7686.6132
.0537	0.6073	220.188	-40068.5506	7991.1550
.0538	0.6291	216.102	-41656.3425	8290.9463
.0539	0.6505	211.858	-43223.5106	8585.0457
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.0541	0.6920	202.905	-46288.9984	9155.3113
.0542	0.7120	198.201	-47783.8433	9431.0563
.0543	0.7316	193.349	-49251.1212	9700.2679
.0544	0.7507	188.333	-51041.6003	9962.4332
.0545	0.7693	183.156	-52493.6385	10217.3471
.0546	0.7873	177.835	-53913.0301	10465.0974
.0547	0.8048	172.374	-55297.9091	10705.4892
.0548	0.8218	166.777	-56646.4375	10938.3328
.0549	0.8382	161.046	-57956.8099	11163.4429
.0550	0.8540	155.187	-59227.2571	11380.6399
.0551	0.8692	149.202	-60456.0499	11589.7493
.0552	0.8838	143.097	-61641.5030	11790.6024
.0553	0.8978	136.876	-62781.9789	11983.0363
.0554	0.9112	130.542	-63875.8915	12166.8944
.0555	0.9239	124.047	-65515.1495	12340.1343
.0556	0.9360	117.444	-66550.8546	12504.4729
.0557	0.9474	110.739	-67533.5391	12659.8177
.0558	0.9581	103.939	-68461.6682	12806.0353
.0559	0.9682	97.049	-69333.7850	12942.9992
.0560	0.9776	90.074	-70148.5138	13070.5906
.0561	0.9862	83.021	-70904.5636	13188.6985
.0562	0.9942	75.895	-71600.7317	13297.2197
.0563	1.0014	68.703	-72235.9060	13396.0592
.0564	1.0079	61.450	-72809.0686	13485.1303
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.0566	1.0187	46.788	-73765.7707	13633.6619
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.0568	1.0266	31.961	-74464.6621	13742.2898
.0569	1.0294	24.501	-74715.9460	13781.5140
.0570	1.0315	17.020	-74901.2076	13810.6288
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.0572	1.0334	2.018	-75072.5591	13838.4356
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.0577	1.0250	-35.403	-74337.5417	13730.3230
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.0580	1.0111	-57.535	-73109.2678	13544.5011
.0581	1.0050	-64.820	-72571.9543	13462.6757
.0582	0.9981	-72.047	-71972.0479	13371.0204
.0583	0.9906	-79.212	-71310.5074	13269.6156
.0584	0.9823	-86.307	-70588.3875	13158.5500
.0585	0.9733	-93.328	-69806.8355	13037.9206
.0586	0.9636	-100.267	-68967.0889	12907.8323
.0587	0.9533	-107.119	-68070.4719	12768.3979
.0588	0.9422	-113.879	-67118.3925	12619.7382

.0589	0.9305	-120.541	-66112.3387	12461.9811
.0590	0.9181	-127.100	-65053.8748	12295.2621
.0591	0.9051	-133.536	-63405.2631	12119.1533
.0592	0.8914	-139.822	-62290.2277	11932.9571
.0593	0.8771	-145.993	-61129.2468	11738.2216
.0594	0.8622	-152.046	-59923.9284	11535.1049
.0595	0.8467	-157.976	-58675.9306	11323.7714
.0596	0.8306	-163.780	-57386.9577	11104.3913
.0597	0.8140	-169.452	-56058.7566	10877.1404
.0598	0.7967	-174.990	-54693.1129	10642.1999
.0599	0.7790	-180.390	-53291.8471	10399.7562
.0600	0.7607	-185.648	-51856.8105	10150.0006

MAXIMUM DEFLECTION	TIME
1.8754	0.0101

INPUT DATA FOR WINBLAST PROGRAM:
****

BLAST PRESSURE = 30 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = 1.06 in.
WINDOW SIZE = 72 x 72
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	1.028	18681.3167	0.4151
0.0002	0.0003	3.829	37350.6676	3.0338
0.0003	0.0009	8.497	55996.0143	10.2939
0.0004	0.0020	15.027	74605.3741	24.6345
0.0005	0.0039	23.416	93166.7874	48.4904
0.0006	0.0068	33.659	111668.3252	84.2899
0.0007	0.0107	45.748	130098.0972	134.4540
0.0008	0.0160	59.675	148444.2591	201.3943
0.0009	0.0227	75.433	166695.0205	287.5116
0.0010	0.0311	93.011	184838.6521	395.1943
0.0011	0.0414	111.425	183434.2581	526.5084
0.0012	0.0534	129.694	181911.9767	681.8343
0.0013	0.0673	147.804	180272.7859	860.9747
0.0014	0.0830	165.744	178517.7394	1063.7168
0.0015	0.1004	183.504	176647.9650	1289.8326
0.0016	0.1197	201.070	174664.6644	1539.0790
0.0017	0.1406	218.433	172569.1122	1811.1980
0.0018	0.1633	235.580	170362.6551	2105.9171
0.0019	0.1877	252.502	168046.7111	2422.9490
0.0020	0.2138	269.186	165622.7687	2761.9922
0.0021	0.2416	285.623	163092.3856	3122.7311
0.0022	0.2710	301.801	160457.1881	3504.8362
0.0023	0.3019	317.711	157718.8696	3907.9640
0.0024	0.3345	333.341	154879.1901	4331.7578
0.0025	0.3686	348.683	151939.9744	4775.8475
0.0026	0.4042	363.726	148903.1116	5239.8498
0.0027	0.4413	378.461	145770.5534	5723.3688
0.0028	0.4799	392.875	142416.1770	6228.2471
0.0029	0.5199	406.938	138817.0009	6772.2491
0.0030	0.5613	420.635	135091.0894	7335.2485
0.0031	0.6040	433.949	131039.7658	7917.1318
0.0032	0.6480	446.850	126959.5952	8519.4708
0.0033	0.6934	459.337	122742.8384	9139.2792
0.0034	0.7399	471.394	118389.5656	9775.9804
0.0035	0.7876	482.973	113449.1202	10427.5893
0.0036	0.8365	494.081	108679.9020	11094.6661
0.0037	0.8864	504.704	103761.8259	11776.6800
0.0038	0.9374	514.801	98053.2205	12469.6603
0.0039	0.9894	524.337	92626.6028	13171.6834
0.0040	1.0422	533.321	87038.2138	13886.3165
0.0041	1.0960	541.739	81289.9392	14612.8053
0.0042	1.1506	549.500	74297.5394	15339.1912
0.0043	1.2059	556.614	67954.4069	16071.2368
0.0044	1.2619	563.085	61442.7420	16812.3710
0.0045	1.3185	568.897	54766.9932	17561.7333
0.0046	1.3756	573.919	46293.9560	18340.1293
0.0047	1.4332	578.184	38973.0964	19131.3027
0.0048	1.4912	581.708	31489.3376	19927.9321

0.0049	1.5496	584.477	23850.8378	20728.9911
0.0050	1.6081	586.356	13805.6486	21564.0224
0.0051	1.6668	587.319	5441.1697	22426.3352
0.0052	1.7255	587.439	-3063.8801	23289.5697
0.0053	1.7843	586.702	-11696.3856	24152.4783
0.0054	1.8429	585.096	-20442.3325	25013.7942
0.0055	1.9012	582.310	-32676.4990	25937.0489
0.0056	1.9593	578.573	-42094.9118	26856.7050
0.0057	2.0169	573.889	-51587.0164	27769.8453
0.0058	2.0740	568.253	-61133.0681	28674.9684
0.0059	2.1305	561.661	-70712.5297	29570.5639
0.0060	2.1863	553.747	-84804.9210	30680.2079
0.0061	2.2412	544.761	-94921.6284	31803.1712
0.0062	2.2952	534.764	-105004.3657	32906.9688
0.0063	2.3482	523.762	-115026.8978	33989.5425
0.0064	2.4000	511.761	-124962.5368	35048.8457
0.0065	2.4505	498.773	-134784.2585	36082.8492
0.0066	2.4997	484.336	-150255.9623	37266.0174
0.0067	2.5473	468.807	-160295.6348	38442.4244
0.0068	2.5934	452.284	-170121.4154	39579.6470
0.0069	2.6377	434.791	-179702.3491	40675.2628
0.0070	2.6803	416.353	-189007.8118	41726.9093
0.0071	2.7210	397.000	-198007.6660	42732.2907
0.0072	2.7597	376.763	-206672.4162	43689.1858
0.0073	2.7963	355.678	-214973.3616	44595.4550
0.0074	2.8308	333.312	-230242.3509	45525.2404
0.0075	2.8629	309.890	-238120.9793	46431.5938
0.0076	2.8927	285.704	-245515.1291	47271.5623
0.0077	2.9201	260.804	-252397.5229	48043.0643
0.0078	2.9449	235.242	-258742.6488	48744.1603
0.0079	2.9671	209.074	-264526.9101	49373.0607
0.0080	2.9867	182.356	-269728.7651	49928.1319
0.0081	3.0035	155.148	-274328.8553	50407.9028
0.0082	3.0177	127.511	-278310.1220	50811.0699
0.0083	3.0290	99.508	-281657.9093	51136.5023
0.0084	3.0376	71.201	-284360.0533	51383.2460
0.0085	3.0433	42.658	-286406.9578	51550.5270
0.0086	3.0461	13.942	-287791.6538	51637.7546
0.0087	3.0460	-14.878	-288509.8452	51644.5230
0.0088	3.0431	-43.737	-288559.9378	51570.6125
0.0089	3.0373	-72.568	-287943.0530	51415.9904
0.0090	3.0286	-101.304	-286663.0254	51180.8107

MAXIMUM DEFLECTION	TIME
3.0464	0.0086

INPUT DATA FOR WINBLAST PROGRAM:
****
BLAST PRESSURE = 40 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = 1.06 in.
WINDOW SIZE = 72 x 72
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0001	1.370	24908.4223	0.5534
0002	0.0004	5.106	49800.8901	4.0450
0003	0.0012	11.329	74661.3524	13.7252
0004	0.0027	20.036	99473.8322	32.8460
0005	0.0052	31.222	124222.3832	64.6538
0006	0.0090	44.878	148891.1002	112.3866
0007	0.0143	60.997	173464.1295	179.2720
0008	0.0213	79.567	197925.6788	268.5257
0009	0.0303	100.578	222260.0273	383.3487
0010	0.0415	124.014	246451.5361	526.9258
0011	0.0551	148.567	244579.0108	702.0112
0012	0.0712	172.925	242549.3022	909.1124
0013	0.0897	197.072	240363.7146	1147.9663
0014	0.1106	220.993	238023.6525	1418.2891
0015	0.1339	244.672	235530.6200	1719.7769
0016	0.1596	268.094	232886.2192	2052.1054
0017	0.1875	291.244	230092.1496	2414.9307
0018	0.2178	314.107	227150.2068	2807.8894
0019	0.2503	336.669	224062.2815	3230.5986
0020	0.2851	358.915	220830.3583	3682.6563
0021	0.3221	380.830	217456.5142	4163.6415
0022	0.3613	402.401	213942.9174	4673.1149
0023	0.4026	423.614	210291.8262	5210.6187
0024	0.4460	444.455	206505.5868	5775.6771
0025	0.4914	464.906	202372.5564	6376.2219
0026	0.5389	484.923	197940.4091	7021.8069
0027	0.5884	504.487	193325.9159	7694.4708
0028	0.6398	523.564	188240.2069	8396.2798
0029	0.6931	542.133	183116.2406	9124.6578
0030	0.7482	560.179	177450.4330	9878.1086
0031	0.8051	577.641	171758.8753	10654.3289
0032	0.8637	594.523	165844.3379	11454.1310
0033	0.9240	610.794	159117.3553	12275.5579
0034	0.9859	626.376	152486.8240	13110.7971
0035	1.0493	641.283	145606.1028	13966.7643
0036	1.1141	655.484	137571.0536	14841.9998
0037	1.1803	668.857	129846.9225	15717.8301
0038	1.2479	681.444	121846.7625	16610.9691
0039	1.3166	693.218	113572.8744	17520.3601
0040	1.3865	704.034	103328.3161	18471.2839
0041	1.4574	713.907	94094.5816	19444.3802
0042	1.5292	722.843	84572.9219	20430.5336
0043	1.6019	730.738	72560.0792	21451.7800
0044	1.6753	737.465	61916.3980	22529.6764
0045	1.7494	743.112	50982.2568	23616.8261
0046	1.8239	747.652	39771.4150	24711.6267
0047	1.8988	750.823	24934.8518	25872.6975
0048	1.9740	752.700	12570.7033	27062.7326

0049	2.0493	753.328	-42.0583	28254.9522
0050	2.1247	752.684	-12880.1087	29447.3633
0051	2.1998	750.379	-30537.6623	30915.8833
0052	2.2747	746.629	-44491.7485	32444.4879
0053	2.3491	741.476	-58607.1429	33964.2958
0054	2.4229	734.904	-72849.5617	35472.4297
0055	2.4960	726.653	-92916.7308	37117.3759
0056	2.5682	716.601	-108119.9703	38895.3841
0057	2.6393	705.028	-123341.4012	40647.1680
0058	2.7092	691.934	-138535.4061	42368.9842
0059	2.7776	677.323	-153655.1959	44057.0944
0060	2.8446	660.878	-176152.2217	45819.6236
0061	2.9098	642.479	-191790.1635	47648.0834
0062	2.9730	622.527	-207190.2419	49423.3329
0063	3.0342	601.050	-222296.6181	51141.0583
0064	3.0932	578.080	-237053.5188	52797.0262
0065	3.1498	553.653	-251405.5609	54387.0992
0066	3.2039	527.680	-274317.5722	55932.9557
0067	3.2552	499.536	-288451.6287	57576.2372
0068	3.3037	470.010	-301970.6087	59128.2092
0069	3.3492	439.165	-314816.4672	60584.5519
0070	3.3915	407.071	-326933.4751	61941.1577
0071	3.4306	373.804	-338268.5951	63194.1494
0072	3.4662	339.445	-348771.8445	64339.8965
0073	3.4984	304.079	-358396.6377	65375.0316
0074	3.5270	267.797	-367100.1086	66296.4654
0075	3.5519	230.691	-374843.4095	67101.4001
0076	3.5731	192.861	-381591.9829	67787.3422
0077	3.5905	154.407	-387315.8058	68352.1133
0078	3.6040	115.433	-391989.6030	68793.8603
0079	3.6136	76.045	-395593.0291	69111.0630
0080	3.6192	36.351	-398110.8163	69302.5413
0081	3.6208	-4.607	-410768.3544	69374.7528
0082	3.6183	-45.650	-399798.1872	69299.2153
0083	3.6117	-85.597	-398961.2423	69103.1358
0084	3.6012	-125.406	-397030.6331	68780.1131
0085	3.5866	-164.967	-394017.7593	68330.7324
0086	3.5682	-204.174	-389939.2072	67755.9175
0087	3.5458	-242.920	-384816.6666	67056.9318
0088	3.5196	-281.103	-378676.7899	66235.3715
0089	3.4896	-318.622	-371551.0184	65293.1570
0090	3.4559	-355.381	-363475.3742	64232.5235

MAXIMUM DEFLECTION	TIME
3.6208	0.0081

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 50 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = 1.06 in.
WINDOW SIZE = 72 x 72
ASPECT RATIO = 1
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0001	1.713	31135.5279	0.6918
0002	0.0004	6.382	62251.1127	5.0563
0003	0.0014	14.161	93326.6906	17.1565
0004	0.0034	25.045	124342.2902	41.0576
0005	0.0066	39.027	155277.9790	80.8173
0006	0.0113	56.098	186113.8753	140.4832
0007	0.0179	76.246	216830.1619	224.0900
0008	0.0266	99.459	247407.0985	335.6572
0009	0.0379	125.722	277825.0341	479.1859
0010	0.0519	155.018	308064.4201	658.6572
0011	0.0689	185.709	305723.7636	877.5140
0012	0.0890	216.156	303186.6278	1136.3905
0013	0.1121	246.340	300454.6432	1434.9578
0014	0.1383	276.241	297529.5657	1772.8614
0015	0.1674	305.839	294413.2750	2149.7211
0016	0.1994	335.117	291107.7740	2565.1317
0017	0.2344	364.055	287615.1870	3018.6634
0018	0.2722	392.634	283937.7585	3509.8618
0019	0.3129	420.836	280077.8519	4038.2483
0020	0.3564	448.643	276037.9478	4603.3203
0021	0.4026	476.038	271820.6427	5204.5519
0022	0.4516	503.002	267428.6468	5841.3936
0023	0.5032	529.508	262542.9510	6528.0326
0024	0.5575	555.503	257316.8967	7265.0738
0025	0.6143	580.958	251625.5504	8038.2859
0026	0.6736	605.829	245751.5179	8848.8528
0027	0.7354	630.099	239612.3575	9693.2068
0028	0.7996	653.708	232711.5177	10568.7995
0029	0.8662	676.636	225816.2810	11476.0189
0030	0.9349	698.846	217984.3522	12411.5796
0031	1.0059	720.256	210155.2893	13369.1684
0032	1.0790	740.865	201985.4785	14355.3067
0033	1.1540	760.586	192359.0555	15357.3366
0034	1.2311	779.361	183069.0204	16375.3296
0035	1.3099	797.187	173395.4699	17417.7044
0036	1.3905	813.911	161614.0368	18510.9763
0037	1.4726	829.529	150672.8815	19638.2554
0038	1.5563	844.031	139315.1030	20786.3899
0039	1.6414	857.208	125027.6603	22013.4929
0040	1.7277	869.070	112150.6869	23280.2808
0041	1.8152	879.623	98837.7514	24563.7361
0042	1.9036	888.618	81701.5967	25926.0270
0043	1.9928	896.046	66778.2450	27337.7652
0044	2.0828	901.960	51430.3637	28760.3092
0045	2.1732	906.172	31333.2641	30340.2533
0046	2.2639	908.457	14316.5898	32191.7897
0047	2.3548	909.022	-3077.7375	34046.5924
0048	2.4457	907.831	-20811.3650	35901.1192

.0049	2.5363	904.362	-45018.8879	38064.2297
.0050	2.6265	898.896	-64349.6718	40284.0044
.0051	2.7160	891.484	-83909.1667	42488.4221
.0052	2.8047	882.108	-103640.8131	44672.6773
.0053	2.8923	870.105	-131557.3205	47097.4346
.0054	2.9787	855.900	-152547.3805	49515.9876
.0055	3.0634	839.596	-173526.4382	51892.4552
.0056	3.1465	821.198	-194419.9122	54220.9693
.0057	3.2276	800.398	-224486.7682	56602.0812
.0058	3.3065	776.864	-246151.7036	59119.0335
.0059	3.3829	751.179	-267477.5018	61558.3696
.0060	3.4567	723.383	-288373.9672	63913.2953
.0061	3.5275	693.522	-308750.9780	66177.1501
0062	3.5953	661.653	-328519.0948	68343.4359
0063	3.6598	627.208	-359388.5666	70556.2331
0064	3.7207	590.298	-378664.7755	72771.7175
0065	3.7778	551.507	-396997.9263	74850.9664
0066	3.8309	510.933	-414296.0005	76787.3168
0067	3.8799	468.685	-430471.2462	78574.4763
0068	3.9246	424.879	-445440.8671	80206.5558
0069	3.9648	379.640	-459127.6771	81678.0988
0070	4.0005	333.099	-471460.7167	82984.1100
0071	4.0314	285.395	-482375.8224	84120.0811
0072	4.0575	236.673	-491816.1456	85082.0141
0073	4.0787	187.083	-499732.6158	85866.4420
0074	4.0949	136.432	-519985.7416	86484.9679
0075	4.1059	84.172	-524927.5808	86959.5080
0076	4.1117	31.506	-528104.3383	87218.7341
0077	4.1122	-21.389	-529499.9428	87261.2698
0078	4.1074	-74.334	-529109.1132	87086.4688
0079	4.0974	-127.151	-526937.4222	86694.4181
0080	4.0820	-179.043	-509297.6344	86119.2467
0081	4.0616	-229.723	-504043.1376	85398.2651
0082	4.0361	-279.799	-497223.5080	84494.8255
0083	4.0057	-329.116	-488879.6384	83411.3370
0084	3.9703	-377.525	-479060.7481	82150.7614
0085	3.9302	-424.881	-467824.0063	80716.5955
0086	3.8854	-471.045	-455234.0945	79112.8510
0087	3.8360	-515.885	-441362.7114	77344.0311
0088	3.7823	-559.277	-426288.0247	75415.1050
0089	3.7242	-601.105	-410094.0763	73331.4799
0090	3.6621	-641.261	-392870.1442	71098.9705

AXIMUM DEFLECTION	TIME
4.1127	0.0077

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 27 x 20
ASPECT RATIO = 1.35
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
.0001	0.0000	0.742	13456.2827	2.3673
.0002	0.0002	2.746	26526.4818	17.2335
.0003	0.0006	6.022	38833.0233	58.0800
.0004	0.0014	10.475	50021.6203	137.6659
.0005	0.0028	15.978	59770.1699	267.6348
.0006	0.0047	22.371	67798.0260	458.1803
.0007	0.0072	29.472	73874.0786	717.7517
.0008	0.0106	37.075	77823.4073	1052.8112
.0009	0.0147	44.961	79532.3169	1467.6481
.0010	0.0196	52.905	78951.6104	1964.2546
0011	0.0252	59.973	62081.9140	2540.5063
0012	0.0315	65.261	43424.9724	3182.4661
0013	0.0382	68.616	23517.8911	3871.0980
0014	0.0452	69.942	2933.7649	4586.0199
0015	0.0521	69.200	-17734.8200	5306.0928
0016	0.0589	66.412	-37892.8459	6010.0296
0017	0.0653	61.658	-56959.9938	6677.0075
0018	0.0712	55.075	-74387.3488	7287.2680
0019	0.0763	46.852	-89673.2036	7822.6850
0020	0.0805	37.227	-102377.5015	8267.2874
0021	0.0837	26.476	-112134.5047	8607.7183
0022	0.0858	14.908	-118663.3237	8833.6198
0023	0.0867	2.858	-121776.0036	8937.9311
0024	0.0864	-9.329	-121382.9351	8917.0920
0025	0.0848	-21.302	-117495.4340	8771.1448
0026	0.0821	-32.715	-110225.4156	8503.7339
0027	0.0783	-43.240	-99782.1728	8122.0002
0028	0.0735	-52.575	-86466.3510	7636.3758
0029	0.0678	-60.450	-70661.2926	7060.2837
0030	0.0615	-66.639	-52822.0017	6409.7514
0031	0.0546	-70.964	-33462.0445	5702.9492
0032	0.0473	-73.299	-13138.7653	4959.6677
0033	0.0400	-73.579	7562.7592	4200.7473
0034	0.0327	-71.794	28046.5633	3447.4788
0035	0.0257	-67.996	47722.9489	2720.9903
0036	0.0192	-62.295	66025.4623	2041.6389
0037	0.0133	-54.855	82427.2018	1428.4248
0038	0.0082	-45.890	96455.9858	898.4439
0039	0.0042	-35.657	107707.9466	466.3964
0040	0.0011	-24.452	115859.1573	144.1628
0041	-0.0007	-12.597	120674.9566	-59.5378
0042	-0.0014	-0.433	122016.7049	-139.3983

AXIMUM DEFLECTION	TIME
0.0867	0.0023

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 32 x 20
ASPECT RATIO = 1.6
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.740	13424.3142	2.2754
0002	0.0002	2.742	26541.4636	16.5782
0003	0.0006	6.028	39049.2663	55.9499
0004	0.0014	10.522	50660.5645	132.8813
0005	0.0028	16.121	61108.7828	259.0007
0006	0.0047	22.697	70154.0477	444.8069
0007	0.0073	30.098	77588.6955	699.4289
0008	0.0107	38.155	83242.0394	1030.4154
0009	0.0150	46.682	86984.2882	1443.5621
0010	0.0201	55.484	88729.5263	1942.7783
0011	0.0261	63.659	74459.2598	2528.3033
0012	0.0328	70.319	58479.5359	3189.2434
0013	0.0401	75.310	41157.2217	3909.8913
0014	0.0478	78.519	22890.0080	4673.1662
0015	0.0557	79.871	4097.2788	5461.0089
0016	0.0637	79.335	-14789.5169	6254.7961
0017	0.0715	76.924	-33336.7706	7035.7680
0018	0.0790	72.693	-51118.6689	7785.4591
0019	0.0860	66.740	-67726.9699	8486.1219
0020	0.0923	59.200	-82780.3754	9121.1346
0021	0.0978	50.247	-95933.2848	9675.3827
0022	0.1023	40.087	-106883.7299	10135.6057
0023	0.1058	28.953	-115380.3070	10490.7021
0024	0.1081	17.100	-121227.9494	10731.9835
0025	0.1092	4.801	-124292.4051	10853.3748
0026	0.1090	-7.663	-124503.3194	10851.5532
0027	0.1076	-20.004	-121855.8502	10726.0249
0028	0.1050	-31.940	-116410.7788	10479.1359
0029	0.1013	-43.197	-108293.1147	10116.0186
0030	0.0964	-53.515	-97689.2256	9644.4738
0031	0.0906	-62.659	-84842.5588	9074.7916
0032	0.0839	-70.419	-70048.0517	8419.5151
0033	0.0766	-76.615	-53645.3610	7693.1525
0034	0.0687	-81.106	-36011.0645	6911.8442
0035	0.0604	-83.790	-17550.0153	6092.9918
0036	0.0520	-84.603	1313.9521	5254.8590
0037	0.0436	-83.528	20147.7535	4416.1522
0038	0.0353	-80.589	38518.9969	3595.5908
0039	0.0275	-75.854	56005.9099	2811.4778
0040	0.0202	-69.431	72207.0229	2081.2792
0041	0.0137	-61.468	86750.3859	1421.2234
0042	0.0080	-52.148	99302.1082	845.9284

AXIMUM DEFLECTION	TIME
0.1093	0.0025

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 72 x 24
ASPECT RATIO = 3
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.709	12881.7874	1.4251
0002	0.0002	2.638	25672.5983	10.4072
0003	0.0006	5.837	38281.4910	35.2580
0004	0.0014	10.285	50619.1178	84.1921
0005	0.0027	15.949	62598.0533	165.2535
0006	0.0046	22.790	74133.4137	286.2585
0007	0.0073	30.758	85143.4585	454.7405
0008	0.0108	39.798	95550.1695	677.8964
0009	0.0153	49.846	105279.8041	962.5355
0010	0.0208	60.829	114263.4170	1315.0316
0011	0.0275	72.001	109035.2238	1740.2171
0012	0.0352	82.610	103034.3978	2236.6752
0013	0.0440	92.583	96303.4613	2800.5538
0014	0.0537	101.848	88890.1104	3427.5216
0015	0.0643	110.340	80846.8767	4112.8002
0016	0.0757	117.998	72230.7553	4851.1980
0017	0.0879	124.769	63102.8006	5637.1470
0018	0.1006	130.604	53527.6941	6464.7424
0019	0.1140	135.462	43573.6615	7327.6368
0020	0.1277	139.308	33310.0870	8218.9054
0021	0.1418	142.116	22806.3651	9132.4931
0022	0.1561	143.864	12127.5101	10061.6603
0023	0.1705	144.538	1359.2378	10999.4109
0024	0.1850	144.135	-9394.6631	11938.7041
0025	0.1993	142.659	-20119.3283	12872.3618
0026	0.2135	140.116	-30703.8957	13793.6421
0027	0.2273	136.525	-41072.9285	14695.6573
0028	0.2407	131.914	-51084.9573	15571.2605
0029	0.2537	126.316	-60814.0652	16413.9363
0030	0.2660	119.766	-70115.3885	17217.7593
0031	0.2776	112.310	-78921.7520	17976.6626
0032	0.2884	104.000	-87169.4064	18684.8963
0033	0.2983	94.897	-94798.5175	19337.0692
0034	0.3074	85.075	-101617.5765	19927.6988
0035	0.3153	74.595	-107850.9140	20452.7905
0036	0.3223	63.530	-113315.1018	20908.3319
0037	0.3280	51.959	-117970.1402	21290.7291
0038	0.3326	39.965	-121781.9151	21596.9100
0039	0.3360	27.632	-124722.4728	21824.3475
0040	0.3381	15.050	-126770.2463	21971.0779
0041	0.3390	2.309	-127910.2296	22035.7148
0042	0.3386	-10.501	-128134.0998	22017.4600
0043	0.3369	-23.287	-127440.2843	21916.1087
0044	0.3340	-35.959	-125833.9732	21732.0514
0045	0.3297	-48.424	-123327.0758	21466.2708
0046	0.3243	-60.595	-119938.1233	21120.3344
0047	0.3176	-72.383	-115692.1164	20696.3831
0048	0.3098	-83.705	-110620.3224	20197.1153

0.0049	0.3009	-94.481	-104760.0206	19625.7670
0.0050	0.2909	-104.641	-98291.6044	18985.6496
0.0051	0.2800	-114.111	-90988.4532	18281.0810
0.0052	0.2681	-122.817	-83040.0995	17516.9615
0.0053	0.2555	-130.699	-74504.3404	16698.4097
0.0054	0.2420	-137.701	-65443.0969	15830.9294
0.0055	0.2280	-143.774	-55994.9121	14920.1699
0.0056	0.2133	-148.881	-46089.2192	13971.7834
0.0057	0.1982	-152.981	-35859.0128	12992.8006
0.0058	0.1828	-156.045	-25377.3281	11989.8487
0.0059	0.1670	-158.053	-14752.1764	10969.4863
0.0060	0.1512	-158.991	-3999.3963	9938.7860
0.0061	0.1353	-158.852	6776.1273	8904.8103
0.0062	0.1194	-157.638	17492.9039	7874.6005
0.0063	0.1038	-155.358	28080.8754	6854.8036
0.0064	0.0884	-152.029	38468.2779	5851.9669
0.0065	0.0734	-147.674	48583.0909	4873.4796
0.0066	0.0589	-142.324	58353.6401	3925.9398
0.0067	0.0450	-136.017	67710.6905	3015.7262
0.0068	0.0317	-128.797	76587.9372	2148.9530
0.0069	0.0192	-120.717	84922.4753	1331.4267
0.0070	0.0076	-111.833	92655.2456	568.6047
0.0071	-0.0031	-102.208	99731.4531	-134.4434
0.0072	-0.0128	-91.911	106100.9551	-773.0711
0.0073	-0.0215	-81.013	111718.6167	-1343.0888
0.0074	-0.0290	-69.593	116544.6309	-1840.7929
0.0075	-0.0354	-57.732	120544.8000	-2262.9923

MAXIMUM DEFLECTION	TIME
0.3390	0.0041

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 75 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 72 x 24
ASPECT RATIO = 3
DAMPING PERCENTAGE = 0 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0001	3.642	66173.5653	7.3209
0.0002	0.0010	13.550	131879.7856	53.4618
0.0003	0.0031	29.987	196651.4946	181.1198
0.0004	0.0072	52.834	260029.7146	432.4935
0.0005	0.0138	81.931	321565.3421	848.9049
0.0006	0.0237	117.071	380822.3305	1470.5062
0.0007	0.0375	158.005	437380.7798	2335.9960
0.0008	0.0555	204.443	490839.9120	3482.3444
0.0009	0.0785	256.056	540820.9113	4944.5315
0.0010	0.1069	312.479	586969.6081	6755.2992
0.0011	0.1410	369.872	560261.6281	8937.9430
0.0012	0.1808	424.389	529402.0075	11486.3170
0.0013	0.2258	475.623	494650.1878	14380.1292
0.0014	0.2758	523.213	456581.9831	17595.3415
0.0015	0.3303	566.833	415306.0982	21107.0918
0.0016	0.3890	606.163	370799.1371	24889.0764
0.0017	0.4514	640.912	323580.3166	28916.1481
0.0018	0.5170	670.803	274037.5924	33156.6137
0.0019	0.5854	695.614	221831.1214	37578.9164
0.0020	0.6560	715.120	168267.5737	42149.1377
0.0021	0.7282	729.166	112414.6662	46833.3082
0.0022	0.8016	737.562	55352.4430	51594.0932
0.0023	0.8756	740.260	-2065.4782	56394.1627
0.0024	0.9495	737.123	-60723.1780	61196.5892
0.0025	1.0228	728.116	-119380.0444	65963.3910
0.0026	1.0949	713.329	-177169.9030	70652.4891
0.0027	1.1653	692.706	-235096.3004	75230.1530
0.0028	1.2333	666.355	-291647.2593	79659.0770
0.0029	1.2983	634.439	-346335.5564	83902.3111
0.0030	1.3600	597.127	-399477.3422	87912.3134
0.0031	1.4176	554.639	-449766.3962	91667.4274
0.0032	1.4707	507.286	-496701.4516	95134.9520
0.0033	1.5189	455.428	-539803.0389	98284.3225
0.0034	1.5617	399.469	-578621.2187	101087.4220
0.0035	1.5987	339.861	-612743.1596	103518.8743
0.0036	1.6295	277.062	-643008.3111	105553.1750
0.0037	1.6540	211.509	-667122.2075	107166.7904
0.0038	1.6718	143.831	-685466.5092	108353.2766
0.0039	1.6827	74.616	-697830.1618	109100.4760
0.0040	1.6867	4.470	-704072.2419	109400.0600
0.0041	1.6836	-65.991	-704124.8419	109247.6240
0.0042	1.6735	-136.148	-697994.4728	108642.7358
0.0043	1.6564	-205.386	-685761.9378	107588.9361
0.0044	1.6325	-273.101	-667580.6782	106093.6915
0.0045	1.6018	-338.667	-642844.4271	104162.7514
0.0046	1.5648	-401.558	-614118.0313	101807.9150
0.0047	1.5216	-461.323	-580376.7408	99054.1055
0.0048	1.4727	-517.478	-541995.5932	95922.8143

0.0049	1.4183	-569.580	-499392.8002	92438.5570
0.0050	1.3589	-617.230	-453022.4091	88628.6065
0.0051	1.2950	-660.075	-403366.6177	84522.7011
0.0052	1.2271	-697.840	-351623.8067	80141.4232
0.0053	1.1556	-730.323	-297690.8106	75526.6326
0.0054	1.0812	-757.317	-241926.8016	70715.2379
0.0055	1.0043	-778.678	-185853.3530	65742.7612
0.0056	0.9256	-794.399	-128454.2257	60641.9047
0.0057	0.8456	-804.354	-70600.9731	55453.9053
0.0058	0.7649	-808.548	-13610.3369	50216.0683
0.0059	0.6841	-807.047	43536.0022	44965.3933
0.0060	0.6037	-799.881	99293.6834	39739.6942
0.0061	0.5243	-787.188	154358.8927	34576.6009
0.0062	0.4465	-769.077	207536.5033	29510.7533
0.0063	0.3707	-745.721	259092.2344	24577.0140
0.0064	0.2975	-717.315	308657.4171	19809.9227
0.0065	0.2274	-684.084	355681.8940	15235.6184
0.0066	0.1608	-646.260	400364.8195	10884.6446
0.0067	0.0983	-604.115	441975.7702	6789.8392
0.0068	0.0401	-557.962	480544.9553	2976.8011
0.0069	-0.0132	-508.120	515708.9584	-526.1262
0.0070	-0.0614	-454.943	547218.6043	-3695.8449
0.0071	-0.1041	-398.807	574850.6131	-6511.6182
0.0072	-0.1410	-340.102	598591.9631	-8953.6610
0.0073	-0.1720	-279.238	617972.5797	-11007.7757
0.0074	-0.1968	-216.657	632898.7827	-12661.2139
0.0075	-0.2153	-152.807	643352.0871	-13904.0995

MAXIMUM DEFLECTION	TIME
1.6867	0.0040

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 26 x 26
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0001	0.0000	0.742	13447.5606	1.5424
0002	0.0002	2.745	26536.9893	11.2219
0003	0.0006	6.030	39043.7523	37.8354
0004	0.0014	10.527	50763.2108	89.8200
0005	0.0028	16.150	61506.1088	175.0979
0006	0.0047	22.790	71101.6017	300.9484
0007	0.0074	30.327	79399.9438	473.8920
0008	0.0108	38.622	86274.7914	699.5880
0009	0.0151	47.530	91625.0894	982.7490
0010	0.0203	56.894	95376.5108	1327.0702
0011	0.0265	65.848	83477.1071	1734.0296
0012	0.0334	73.546	70294.8422	2197.8421
0013	0.0411	79.872	56065.0668	2709.7446
0014	0.0494	84.733	41038.3380	3260.2533
0015	0.0580	88.062	25476.0407	3839.3324
0016	0.0669	89.819	9645.8732	4436.5686
0017	0.0759	89.991	-6182.7284	5041.3510
0018	0.0849	88.591	-21743.1465	5643.0513
0019	0.0936	85.660	-36776.0443	6231.2033
0020	0.1020	81.262	-51033.6584	6795.6775
0021	0.1098	75.487	-64283.8528	7326.8483
0022	0.1170	68.446	-76313.8673	7815.7508
0023	0.1235	60.271	-86933.7004	8254.2249
0024	0.1290	51.112	-95979.0745	8635.0448
0025	0.1337	41.133	-103313.9361	8952.0305
0026	0.1372	30.510	-108832.4554	9200.1415
0027	0.1397	19.430	-112460.4957	9375.5496
0028	0.1411	8.083	-114156.5338	9475.6911
0029	0.1414	-3.336	-113912.0216	9499.2968
0030	0.1405	-14.635	-111751.1883	9446.3995
0031	0.1384	-25.624	-107730.2924	9318.3209
0032	0.1353	-36.122	-101936.3424	9117.6351
0033	0.1312	-45.956	-94485.3122	8848.1127
0034	0.1262	-54.968	-85519.8876	8514.6446
0035	0.1203	-63.015	-75206.7857	8123.1485
0036	0.1136	-69.971	-63733.6975	7680.4581
0037	0.1063	-75.730	-51305.9092	7194.1986
0038	0.0985	-80.207	-38142.6613	6672.6501
0039	0.0903	-83.341	-24473.3113	6124.6015
0040	0.0819	-85.093	-10533.3651	5559.1968

MAXIMUM DEFLECTION	TIME
0.1414	0.0029

INPUT DATA FOR WINBLAST PROGRAM:
****

BLAST PRESSURE = 7.3 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .355 in.
WINDOW SIZE = 26 x 26
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.745	13523.8311	0.7731
0.0002	0.0002	2.768	26923.9483	5.6416
0.0003	0.0006	6.123	40140.6481	19.1023
0.0004	0.0015	10.788	53119.0198	45.6008
0.0005	0.0028	16.737	65805.4451	89.5046
0.0006	0.0049	23.938	78147.8183	155.0845
0.0007	0.0077	32.354	90095.7587	246.4980
0.0008	0.0114	41.942	101600.8144	367.7715
0.0009	0.0161	52.657	112616.6572	522.7844
0.0010	0.0219	64.448	123099.2674	715.2532
0.0011	0.0290	76.554	118935.4944	948.1415
0.0012	0.0372	88.219	114290.6420	1221.1185
0.0013	0.0466	99.396	109186.8419	1532.6412
0.0014	0.0571	110.042	103648.0511	1881.0107
0.0015	0.0686	120.112	97699.9404	2264.3810
0.0016	0.0811	129.569	91369.7777	2680.7683
0.0017	0.0945	138.374	84686.3039	3128.0589
0.0018	0.1087	146.495	77679.6037	3604.0200
0.0019	0.1238	153.901	70380.9722	4106.3090
0.0020	0.1395	160.563	62822.7753	4632.4840
0.0021	0.1559	166.458	55038.3084	5180.0152
0.0022	0.1728	171.527	46329.6694	5765.2353
0.0023	0.1901	175.719	37454.6450	6372.6899
0.0024	0.2079	178.989	27825.1750	6994.8027
0.0025	0.2259	181.297	18287.8696	7628.8449
0.0026	0.2441	182.641	8577.5761	8269.6631
0.0027	0.2624	182.943	-2242.5573	8912.7313
0.0028	0.2807	182.207	-12481.9169	9554.9610
0.0029	0.2988	180.445	-22759.2729	10193.1631
0.0030	0.3167	177.580	-34516.7863	10819.8039
0.0031	0.3343	173.598	-45103.9517	11431.8667
0.0032	0.3514	168.564	-55536.7822	12028.6206
0.0033	0.3680	162.498	-65737.4962	12606.4346
0.0034	0.3839	155.262	-77996.8149	13152.8756
0.0035	0.3990	146.961	-87940.5744	13670.2785
0.0036	0.4132	137.691	-97387.6463	14158.0960
0.0037	0.4265	127.503	-106251.7116	14613.0968
0.0038	0.4387	116.463	-114450.0798	15032.2455
0.0039	0.4497	104.495	-125170.6793	15418.6263
0.0040	0.4596	91.623	-132120.4975	15769.4734
0.0041	0.4680	78.103	-138123.9190	16073.9454
0.0042	0.4752	64.032	-143118.3036	16329.8909
0.0043	0.4808	49.514	-147052.0780	16535.5119
0.0044	0.4850	34.658	-149885.6861	16689.3832
0.0045	0.4878	19.575	-151592.3145	16790.4659
0.0046	0.4890	4.378	-152158.3756	16838.1183
0.0047	0.4886	-10.818	-151583.7363	16832.1000
0.0048	0.4868	-25.901	-149881.6887	16772.5736

0.0049	0.4835	-40.758	-147078.6637	16660.0995
0.0050	0.4787	-55.281	-143213.6975	16495.6277
0.0051	0.4724	-69.367	-138337.6642	16280.4841
0.0052	0.4648	-82.917	-132512.2974	16016.3533
0.0053	0.4559	-95.840	-125809.0237	15705.2569
0.0054	0.4457	-108.052	-118307.6414	15349.5287

MAXIMUM DEFLECTION	TIME
0.4890	0.0046

INPUT DATA FOR WINBLAST PROGRAM:
****
BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .801 in.
WINDOW SIZE = 26 x 26
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.657	11898.9759	1.5412
0.0002	0.0002	2.427	23411.9259	11.2029
0.0003	0.0005	5.318	34288.9459	37.7180
0.0004	0.0013	9.256	44304.5106	89.3729
0.0005	0.0024	14.143	53254.1798	173.8190
0.0006	0.0041	19.865	60958.7301	297.9158
0.0007	0.0064	26.288	67267.6992	467.5934
0.0008	0.0094	33.267	72062.2719	687.7367
0.0009	0.0131	40.647	75257.4556	962.0923
0.0010	0.0175	48.264	76803.5051	1293.2023
0.0011	0.0227	55.330	64290.2081	1681.2150
0.0012	0.0286	61.080	50546.1955	2118.8724
0.0013	0.0349	65.408	35880.2045	2595.8606
0.0014	0.0416	68.237	20617.1115	3101.1422
0.0015	0.0485	69.523	5090.7852	3623.2031
0.0016	0.0554	69.257	-10363.1685	4150.3039
0.0017	0.0623	67.464	-25414.6150	4670.7347
0.0018	0.0689	64.198	-39745.8974	5173.0653
0.0019	0.0751	59.549	-53058.4938	5646.3865
0.0020	0.0808	53.630	-65079.1879	6080.5381
0.0021	0.0858	46.584	-75565.6241	6466.3172
0.0022	0.0900	38.575	-84311.1381	6795.6648
0.0023	0.0935	29.786	-91148.7657	7061.8244
0.0024	0.0960	20.414	-95954.3551	7259.4718
0.0025	0.0975	10.666	-98648.7255	7384.8124
0.0026	0.0981	0.756	-99198.8376	7435.6445
0.0027	0.0977	-9.103	-97617.9622	7411.3878
0.0028	0.0963	-18.698	-93964.8547	7313.0772
0.0029	0.0940	-27.830	-88341.9654	7143.3213
0.0030	0.0908	-36.306	-80892.7350	6906.2285
0.0031	0.0867	-43.953	-71798.0431	6607.3014
0.0032	0.0820	-50.617	-61271.8974	6253.3025
0.0033	0.0766	-56.167	-49556.4627	5852.0949
0.0034	0.0708	-60.498	-36916.5460	5412.4609
0.0035	0.0646	-63.529	-23633.6599	4943.9030
0.0036	0.0581	-65.213	-9999.7988	4456.4323
0.0037	0.0516	-65.527	3688.9379	3960.3481
0.0038	0.0451	-64.483	17138.7346	3466.0136
0.0039	0.0387	-62.117	30064.3262	2983.6336
0.0040	0.0327	-58.497	42195.0074	2523.0376
0.0041	0.0271	-53.713	53280.2606	2093.4736
0.0042	0.0220	-47.883	63094.8851	1703.4172
0.0043	0.0175	-41.143	71443.5247	1360.3986
0.0044	0.0138	-33.649	78164.5029	1070.8527
0.0045	0.0108	-25.569	83132.8922	839.9940
0.0046	0.0087	-17.084	86262.7601	671.7189
0.0047	0.0074	-8.380	87508.5542	568.5384
0.0048	0.0070	0.354	86865.6057	531.5396

0.0049	0.0075	8.931	84369.7520	560.3796
0.0050	0.0088	17.169	80096.0958	653.3096
0.0051	0.0109	24.895	74156.9379	807.2283
0.0052	0.0137	31.949	66698.9375	1017.7646
0.0053	0.0173	38.189	57899.5692	1279.3859
0.0054	0.0213	43.491	47962.9630	1585.5301

MAXIMUM DEFLECTION	TIME
0.0981	0.0026

INPUT DATA FOR WINBLAST PROGRAM:
****
BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 36 x 36
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.745	13521.0465	0.8064
0.0002	0.0002	2.768	26910.5095	5.8842
0.0003	0.0006	6.120	40103.6455	19.9209
0.0004	0.0015	10.780	53040.8399	47.5465
0.0005	0.0028	16.718	65663.9780	93.3030
0.0006	0.0048	23.900	77916.7046	161.6246
0.0007	0.0076	32.287	89744.6736	256.8178
0.0008	0.0113	41.833	101095.7868	383.0419
0.0009	0.0160	52.488	111920.4217	544.2911
0.0010	0.0219	64.198	122171.6459	744.3769
0.0011	0.0289	76.198	117736.2654	986.3111
0.0012	0.0371	87.728	112783.4209	1269.6551
0.0013	0.0464	98.738	107338.6959	1592.6924
0.0014	0.0568	109.180	101429.7977	1953.5324
0.0015	0.0682	119.009	95086.4183	2350.1209
0.0016	0.0806	128.184	88340.0869	2780.2507
0.0017	0.0939	136.665	81224.0155	3241.5717
0.0018	0.1079	144.417	73772.9362	3731.6037
0.0019	0.1227	151.409	66022.9339	4247.7474
0.0020	0.1382	157.613	58011.2729	4787.2979
0.0021	0.1542	163.004	49776.2187	5347.4569
0.0022	0.1707	167.562	41356.8572	5925.3469
0.0023	0.1877	171.271	32792.9098	6518.0241
0.0024	0.2050	174.117	24124.5481	7122.4928
0.0025	0.2225	176.094	15392.2057	7735.7193
0.0026	0.2402	177.195	6636.3919	8354.6460
0.0027	0.2579	177.421	-2102.4960	8976.2057
0.0028	0.2756	176.776	-10784.3573	9597.3358
0.0029	0.2932	175.268	-19369.5709	10214.9920
0.0030	0.3106	172.907	-27819.1748	10826.1628
0.0031	0.3278	169.672	-36949.9358	11442.9939
0.0032	0.3445	165.540	-45645.4524	12057.7298
0.0033	0.3609	160.550	-54114.9431	12656.0934
0.0034	0.3766	154.727	-62312.4721	13234.9796
0.0035	0.3918	148.098	-70192.9655	13791.3812
0.0036	0.4062	140.657	-78703.9772	14323.6468
0.0037	0.4199	132.419	-85982.2086	14828.6516
0.0038	0.4327	123.476	-92805.9832	15302.3328
0.0039	0.4446	113.875	-99134.1112	15742.1664
0.0040	0.4554	103.667	-104928.1916	16145.8093
0.0041	0.4653	92.908	-110152.9962	16511.1130
0.0042	0.4740	81.656	-114776.8292	16836.1371
0.0043	0.4816	69.974	-118771.8549	17119.1606
0.0044	0.4880	57.924	-122114.3880	17358.6925
0.0045	0.4932	45.573	-124785.1423	17553.4809
0.0046	0.4971	32.918	-128381.4074	17702.3372
0.0047	0.4997	20.008	-129697.1353	17804.1355
0.0048	0.5011	7.003	-130280.0560	17858.4388

.0049	0.5011	-6.023	-130129.9149	17865.0064
.0050	0.4999	-18.999	-129251.9352	17823.8664
.0051	0.4973	-31.850	-127656.7444	17735.3139
.0052	0.4935	-44.467	-123810.2596	17599.8256
.0053	0.4885	-56.710	-120933.5901	17418.3321
.0054	0.4822	-68.633	-117427.9629	17192.2997
.0055	0.4747	-80.175	-113320.9009	16922.9930
.0056	0.4662	-91.278	-108643.6725	16611.8990
.0057	0.4565	-101.886	-103430.9529	16260.7148
.0058	0.4458	-111.948	-97720.4565	15871.3361
.0059	0.4341	-121.415	-91552.5452	15445.8423
.0060	0.4215	-130.244	-84969.8200	14986.4829
.0061	0.4081	-138.396	-78016.7009	14495.6609
.0062	0.3939	-145.824	-69903.0925	13976.3288
.0063	0.3790	-152.447	-62520.6638	13433.1149
.0064	0.3634	-158.320	-54906.6418	12866.7688
.0065	0.3473	-163.422	-47105.5667	12280.0661
.0066	0.3308	-167.737	-39161.9492	11675.8525
.0067	0.3138	-171.249	-30673.8468	11057.9997
.0068	0.2965	-173.939	-23105.0705	10453.8570
.0069	0.2791	-175.868	-15471.0437	9841.3521
.0070	0.2614	-177.032	-7807.2309	9223.1580
.0071	0.2437	-177.430	-149.0414	8601.9589
.0072	0.2259	-177.063	7468.3332	7980.4385
.0073	0.2083	-175.939	15010.0799	7361.2674
.0074	0.1908	-174.065	22441.9220	6747.0909
.0075	0.1735	-171.455	29730.2742	6140.5169

MAXIMUM DEFLECTION	TIME
0.5013	0.0048

INPUT DATA FOR WINBLAST PROGRAM:
****
BLAST PRESSURE = 7.3 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .355 in.
WINDOW SIZE = 36 x 36
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.746	13551.5534	0.4036
0.0002	0.0002	2.776	27052.6218	2.9484
0.0003	0.0006	6.154	40485.9017	9.9966
0.0004	0.0015	10.871	53836.1059	23.9032
0.0005	0.0028	16.918	67088.0842	47.0089
0.0006	0.0049	24.285	80226.8405	81.6376
0.0007	0.0077	32.959	93237.5501	130.0934
0.0008	0.0115	42.927	106105.5758	194.6583
0.0009	0.0164	54.175	118816.4843	277.5897
0.0010	0.0224	66.685	131356.0628	381.1176
0.0011	0.0297	79.735	129613.9403	507.1417
0.0012	0.0384	92.603	127727.2665	655.9074
0.0013	0.0482	105.275	125698.6067	827.0870
0.0014	0.0594	117.738	123530.6825	1020.3275
0.0015	0.0718	129.977	121226.3686	1235.2515
0.0016	0.0854	141.979	118788.6889	1471.4577
0.0017	0.1002	153.730	116220.8128	1728.5212
0.0018	0.1161	165.219	113526.0510	2005.9944
0.0019	0.1332	176.431	110707.8514	2303.4073
0.0020	0.1514	187.356	107769.7946	2620.2682
0.0021	0.1707	197.973	104490.9734	2964.1610
0.0022	0.1910	208.249	101001.5725	3333.7453
0.0023	0.2123	218.160	97170.2008	3722.8580
0.0024	0.2346	227.682	93242.7344	4130.7742
0.0025	0.2578	236.794	88873.5616	4555.5586
0.0026	0.2819	245.462	84451.6232	4996.0843
0.0027	0.3069	253.678	79833.5812	5452.1720
0.0028	0.3327	261.378	74451.4317	5917.8981
0.0029	0.3592	268.563	69216.1220	6397.1213
0.0030	0.3864	275.184	63059.6342	6883.9328
0.0031	0.4142	281.195	57124.6247	7376.8175
0.0032	0.4426	286.602	50963.0802	7879.9474
0.0033	0.4715	291.294	43424.3254	8408.3681
0.0034	0.5008	295.292	36505.0391	8947.7051
0.0035	0.5305	298.581	28053.5947	9496.0598
0.0036	0.5605	300.999	20285.4712	10085.8623
0.0037	0.5907	302.631	12307.6728	10679.8099
0.0038	0.6210	303.445	2265.5969	11279.8731
0.0039	0.6513	303.233	-6530.2680	11923.4078
0.0040	0.6816	302.134	-15477.2145	12565.7435
0.0041	0.7117	300.134	-24542.1988	13204.9855
0.0042	0.7416	296.991	-36642.5276	13990.8752
0.0043	0.7711	292.841	-46363.2909	14798.5249
0.0044	0.8001	287.718	-56092.2526	15593.7646
0.0045	0.8286	281.573	-69174.0428	16398.6064
0.0046	0.8564	274.147	-79333.7787	17317.0167
0.0047	0.8834	265.711	-89347.7338	18209.6191
0.0048	0.9095	256.284	-99159.8612	19073.1093

0.0049	0.9346	245.888	-108714.0016	19904.2478
0.0050	0.9586	234.212	-122672.2122	20776.2513
0.0051	0.9814	221.474	-132028.8176	21635.1159
0.0052	1.0029	207.822	-140923.6684	22444.8618
0.0053	1.0230	193.306	-149298.2774	23202.1392
0.0054	1.0415	177.982	-157097.0689	23903.7912
0.0055	1.0585	161.908	-164267.9614	24546.8744
0.0056	1.0739	145.014	-176267.4276	25146.5070
0.0057	1.0875	127.076	-182365.7067	25734.1562
0.0058	1.0993	108.569	-187634.9397	26244.3582
0.0059	1.1092	89.578	-192037.1604	26674.8324
0.0060	1.1172	70.191	-195541.2338	27023.6664
0.0061	1.1232	50.500	-198123.2113	27289.3288
0.0062	1.1273	30.598	-199766.5981	27470.6801
0.0063	1.1294	10.579	-200462.5311	27566.9802
0.0064	1.1294	-9.463	-200209.8640	27577.8920
0.0065	1.1275	-29.431	-199015.1588	27503.4826
0.0066	1.1235	-49.234	-196892.5860	27344.2208
0.0067	1.1176	-68.780	-193863.7341	27100.9714
0.0068	1.1098	-87.978	-189957.3315	26774.9859
0.0069	1.1000	-106.743	-185208.8873	26367.8912
0.0070	1.0885	-124.993	-179660.2541	25881.6744
0.0071	1.0751	-142.650	-173359.1216	25318.6654
0.0072	1.0600	-159.408	-161281.0732	24719.9138
0.0073	1.0432	-175.182	-154106.7324	24098.6935
0.0074	1.0249	-190.212	-146395.8978	23419.4621

MAXIMUM DEFLECTION	TIME
1.1296	0.0063

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .8090000000000001 in.
WINDOW SIZE = 36 x 36
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.653	11857.9055	0.8062
0.0002	0.0002	2.426	23575.7485	5.8801
0.0003	0.0006	5.361	35080.5570	19.8971
0.0004	0.0013	9.433	46304.9810	47.4588
0.0005	0.0025	14.611	57183.7602	93.0576
0.0006	0.0042	20.856	67654.0996	161.0506
0.0007	0.0067	28.126	77656.0297	255.6342
0.0008	0.0099	36.370	87132.7468	380.8205
0.0009	0.0140	45.533	96030.9324	540.4138
0.0010	0.0190	55.555	104301.0500	737.9899
0.0011	0.0251	65.753	99557.6566	976.2754
0.0012	0.0322	75.447	94249.3470	1254.4971
0.0013	0.0402	84.585	88411.2898	1570.5592
0.0014	0.0491	93.113	82081.5984	1922.1522
0.0015	0.0588	100.986	75301.0851	2306.7687
0.0016	0.0692	108.160	68113.0009	2721.7197
0.0017	0.0804	114.596	60562.7623	3164.1518
0.0018	0.0921	120.262	52697.6672	3631.0652
0.0019	0.1044	125.127	44566.6006	4119.3324
0.0020	0.1171	129.168	36219.7329	4625.7179
0.0021	0.1302	132.365	27708.2133	5146.8979
0.0022	0.1436	134.706	19083.8577	5679.4809
0.0023	0.1571	136.180	10398.8355	6220.0283
0.0024	0.1708	136.785	1705.3565	6765.0752
0.0025	0.1845	136.523	-6944.6415	7311.1510
0.0026	0.1981	135.399	-15499.8007	7854.8007
0.0027	0.2115	133.428	-23909.6465	8392.6050
0.0028	0.2247	130.624	-32124.8829	8921.2004
0.0029	0.2376	127.011	-40097.6798	9437.2994
0.0030	0.2501	122.614	-47781.9493	9937.7092
0.0031	0.2621	117.466	-55133.6098	10419.3505
0.0032	0.2736	111.600	-62110.8371	10879.2748
0.0033	0.2844	105.057	-68674.2999	11314.6816
0.0034	0.2945	97.880	-74787.3792	11722.9339
0.0035	0.3040	90.116	-80416.3698	12101.5732
0.0036	0.3126	81.814	-85530.6641	12448.3328
0.0037	0.3203	73.028	-90102.9150	12761.1502
0.0038	0.3271	63.813	-94109.1795	13038.1782
0.0039	0.3330	54.226	-97529.0402	13277.7949
0.0040	0.3380	44.327	-100345.7058	13478.6114
0.0041	0.3419	34.177	-102546.0886	13639.4789
0.0042	0.3448	23.839	-104120.8598	13759.4944
0.0043	0.3467	13.374	-105064.4822	13838.0041
0.0044	0.3475	2.847	-105375.2196	13874.6059
0.0045	0.3472	-7.680	-105055.1238	13869.1505
0.0046	0.3459	-18.143	-104109.9988	13821.7404
0.0047	0.3436	-28.481	-102549.3436	13732.7279
0.0048	0.3403	-38.633	-100386.2717	13602.7115

0.0049	0.3359	-48.539	-97637.4116	13432.5305
0.0050	0.3306	-58.141	-94322.7850	13223.2589
0.0051	0.3243	-67.385	-90465.6669	12976.1975
0.0052	0.3171	-76.217	-86092.4263	12692.8644
0.0053	0.3091	-84.587	-81232.3498	12374.9848
0.0054	0.3002	-92.448	-75917.4491	12024.4797
0.0055	0.2906	-99.757	-70182.2525	11643.4527
0.0056	0.2803	-106.472	-64063.5839	11234.1766
0.0057	0.2693	-112.558	-57600.3285	10799.0790
0.0058	0.2578	-117.982	-50833.1881	10340.7263
0.0059	0.2457	-122.716	-43804.4270	9861.8081
0.0060	0.2333	-126.735	-36557.6101	9365.1201
0.0061	0.2204	-130.021	-29137.3347	8853.5467
0.0062	0.2073	-132.559	-21588.9583	8330.0435
0.0063	0.1939	-134.336	-13958.3228	7797.6188
0.0064	0.1804	-135.349	-6291.4781	7259.3159
0.0065	0.1669	-135.595	1365.5938	6718.1941
0.0066	0.1533	-135.078	8967.2533	6177.3108
0.0067	0.1399	-133.805	16468.4732	5639.7032
0.0068	0.1266	-131.789	23825.1035	5108.3700
0.0069	0.1136	-129.046	30994.1298	4586.2540
0.0070	0.1008	-125.598	37933.9228	4076.2249
0.0071	0.0885	-121.468	44604.4785	3581.0625
0.0072	0.0765	-116.687	50967.6465	3103.4407
0.0073	0.0651	-111.286	56987.3465	2645.9123
0.0074	0.0543	-105.302	62629.7710	2210.8942

MAXIMUM DEFLECTION	TIME
0.3475	0.0044

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .71 in.
WINDOW SIZE = 40 x 40
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
.0001	0.0000	0.745	13533.4379	0.6535
.0002	0.0002	2.771	26969.6861	4.7704
.0003	0.0006	6.134	40265.4899	16.1602
.0004	0.0015	10.818	53381.3192	38.6008
.0005	0.0028	16.803	66278.3607	75.8202
.0006	0.0049	24.065	78918.6320	131.4854
.0007	0.0077	32.577	91265.0931	209.1913
.0008	0.0114	42.307	103281.7539	312.4509
.0009	0.0162	53.221	114933.7779	444.6843
.0010	0.0221	65.281	126187.5830	609.2093
.0011	0.0293	77.740	122930.8010	808.7450
.0012	0.0376	89.855	119317.1282	1043.2655
.0013	0.0472	101.592	115359.0435	1311.7559
.0014	0.0579	112.916	111070.0110	1613.1025
.0015	0.0698	123.795	106464.4350	1946.0974
.0016	0.0827	134.198	101557.6125	2309.4423
.0017	0.0966	144.097	96365.6826	2701.7531
.0018	0.1115	153.463	90905.5748	3121.5640
.0019	0.1273	162.270	85194.9538	3567.3330
.0020	0.1439	170.494	79252.1631	4037.4463
.0021	0.1614	178.113	73096.1670	4530.2237
.0022	0.1795	185.107	66746.4899	5043.9238
.0023	0.1984	191.456	60223.1555	5576.7500
.0024	0.2178	197.146	53546.6240	6126.8555
.0025	0.2378	202.161	46737.7280	6692.3497
.0026	0.2582	206.490	39817.6088	7271.3037
.0027	0.2790	210.122	32807.6501	7861.7563
.0028	0.3002	213.049	25729.4135	8461.7205
.0029	0.3216	215.260	18188.2836	9073.2874
.0030	0.3432	216.695	10485.6145	9712.8451
.0031	0.3649	217.356	2726.2630	10355.7367
.0032	0.3867	217.239	-5063.9939	10999.6655
.0033	0.4084	216.320	-13535.9802	11643.5411
.0034	0.4299	214.568	-21491.9560	12285.5590
.0035	0.4513	212.023	-29403.7659	12921.4169
.0036	0.4723	208.690	-37241.0453	13548.7585
.0037	0.4930	204.578	-44972.9450	14165.2493
.0038	0.5132	199.612	-53825.6382	14767.4132
.0039	0.5329	193.845	-61486.2734	15353.5667
.0040	0.5519	187.322	-68945.3713	15921.6893
.0041	0.5703	180.064	-76168.7536	16469.5603
.0042	0.5879	172.097	-83122.6877	16995.0278
.0043	0.6047	163.450	-89774.1503	17496.0189
.0044	0.6206	154.051	-98014.9503	17967.4574
.0045	0.6355	143.937	-104196.6779	18408.2314
.0046	0.6493	133.226	-109963.2977	18818.5848
.0047	0.6621	121.960	-115283.8206	19196.8118
.0048	0.6737	110.185	-120129.5042	19541.3367

.0049	0.6841	97.951	-124474.1312	19850.7226
.0050	0.6933	85.308	-128294.2659	20123.6788
.0051	0.7012	72.310	-131569.4856	20359.0679
.0052	0.7078	59.013	-134282.5831	20555.9121
.0053	0.7130	45.473	-136419.7380	20713.3981
.0054	0.7168	31.748	-137970.6537	20830.8812
.0055	0.7193	17.899	-138928.6586	20907.8887
.0056	0.7204	3.983	-139290.7697	20944.1219
.0057	0.7201	-9.940	-139057.7184	20939.4569
.0058	0.7184	-23.809	-138233.9375	20893.9445
.0059	0.7154	-37.567	-136827.5096	20807.8094
.0060	0.7109	-51.155	-134850.0793	20681.4473
.0061	0.7051	-64.518	-132316.7280	20515.4222
.0062	0.6980	-77.601	-129245.8155	20310.4616
.0063	0.6896	-90.350	-125658.7899	20067.4517
.0064	0.6800	-102.716	-121579.9680	19787.4306
.0065	0.6691	-114.651	-117036.2912	19471.5816
.0066	0.6571	-126.109	-112057.0579	19121.2255
.0067	0.6439	-137.049	-106673.6388	18737.8118
.0068	0.6297	-147.431	-100919.1769	18322.9094
.0069	0.6144	-157.221	-94828.2780	17878.1974
.0070	0.5982	-166.280	-86887.6134	17402.3573
.0071	0.5812	-174.652	-80498.3676	16898.4295
.0072	0.5633	-182.373	-73885.7878	16370.4074
.0073	0.5447	-189.423	-67083.4001	15820.2478
.0074	0.5255	-195.784	-60124.7581	15249.9649
.0075	0.5056	-201.443	-53043.2038	14661.6203

MAXIMUM DEFLECTION	TIME
0.7205	0.0056

INPUT DATA FOR WINBLAST PROGRAM:

****

BLAST PRESSURE = 7.3 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .355 in.
WINDOW SIZE = 40 x 40
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
0.0001	0.0000	0.746	13556.5818	0.3270
0.0002	0.0002	2.778	27074.6399	2.3891
0.0003	0.0006	6.159	40542.5168	8.1019
0.0004	0.0015	10.884	53950.1430	19.3777
0.0005	0.0029	16.947	67287.5168	38.1203
0.0006	0.0049	24.339	80544.7112	66.2238
0.0007	0.0078	33.053	93711.8821	105.5709
0.0008	0.0116	43.078	106779.2749	158.0317
0.0009	0.0164	54.405	119737.2317	225.4625
0.0010	0.0225	67.022	132576.1987	309.7038
0.0011	0.0298	80.211	131185.7698	412.3364
0.0012	0.0385	93.256	129699.2395	533.6080
0.0013	0.0485	106.147	128117.9427	673.3094
0.0014	0.0597	118.876	126443.2831	831.2174
0.0015	0.0723	131.433	124676.7315	1007.0957
0.0016	0.0860	143.808	122819.8254	1200.6949
0.0017	0.1010	155.994	120874.1669	1411.7527
0.0018	0.1172	167.980	118841.4216	1639.9941
0.0019	0.1346	179.759	116723.3177	1885.1320
0.0020	0.1532	191.322	114521.6436	2146.8669
0.0021	0.1729	202.653	112043.4124	2432.7726
0.0022	0.1937	213.727	109420.0954	2739.5301
0.0023	0.2156	224.526	106540.7037	3063.5711
0.0024	0.2386	235.033	103590.5139	3404.0332
0.0025	0.2626	245.230	100310.6911	3759.5238
0.0026	0.2876	255.096	96991.1137	4129.5757
0.0027	0.3136	264.617	93241.9592	4513.0846
0.0028	0.3405	273.753	89462.5390	4907.1426
0.0029	0.3683	282.504	85515.2414	5314.3946
0.0030	0.3970	290.811	80844.6947	5726.9306
0.0031	0.4265	298.672	76344.3631	6149.6858
0.0032	0.4567	306.051	70987.4037	6588.6533
0.0033	0.4877	312.896	65881.3325	7049.2011
0.0034	0.5193	319.221	60573.5820	7519.6486
0.0035	0.5515	324.941	53987.1251	8022.3536
0.0036	0.5843	330.040	47955.5032	8543.8145
0.0037	0.6175	334.525	41717.9926	9073.0170
0.0038	0.6511	338.244	33717.3720	9648.5111
0.0039	0.6851	341.268	26725.5359	10231.7550
0.0040	0.7194	343.574	17838.5489	10829.9532
0.0041	0.7538	344.971	10072.9925	11592.1908
0.0042	0.7883	345.583	2132.9035	12356.8302
0.0043	0.8229	345.393	-5959.8558	13122.1164
0.0044	0.8574	344.157	-16824.8564	14034.0515
0.0045	0.8917	342.035	-25630.0697	14950.6595
0.0046	0.9258	339.028	-34520.8991	15860.6600
0.0047	0.9595	334.992	-46613.7347	16823.0589
0.0048	0.9927	329.858	-56071.9140	17833.8804

.0049	1.0254	323.778	-65516.7779	18827.9693
.0050	1.0574	316.756	-74908.1197	19802.4587
.0051	1.0887	308.593	-88113.7573	20823.7786
.0052	1.1191	299.296	-97802.9616	21876.4908
.0053	1.1485	289.039	-107301.6328	22895.7777
.0054	1.1769	277.843	-116561.8840	23878.3545
.0055	1.2041	265.736	-125536.2361	24821.0168
.0056	1.2300	252.445	-138985.5463	25793.6380
.0057	1.2545	238.107	-147702.3952	26762.0690
.0058	1.2776	222.919	-155960.2938	27672.8863
.0059	1.2991	206.932	-163711.1912	28522.8321
.0060	1.3190	190.196	-170909.6846	29308.8453
.0061	1.3371	172.770	-177513.4373	30028.0802
.0062	1.3535	154.714	-183483.5684	30677.9224
.0063	1.3680	136.095	-188785.0109	31256.0047
.0064	1.3807	116.560	-199085.2781	31810.5533
.0065	1.3913	96.442	-203153.4429	32294.1847
.0066	1.4000	75.957	-206405.9017	32687.4945
.0067	1.4065	55.188	-208823.2956	32988.9976
.0068	1.4110	34.221	-210392.1931	33197.5799
.0069	1.4134	13.139	-211105.2174	33312.5047
.0070	1.4136	-7.972	-210961.1088	33333.4160
.0071	1.4118	-29.025	-209964.7232	33260.3400
.0072	1.4078	-49.937	-208126.9657	33093.6821
.0073	1.4018	-70.623	-205464.6605	32834.2237
.0074	1.3937	-91.003	-202000.3601	32483.1136
.0075	1.3836	-110.997	-197762.0966	32041.8592
.0076	1.3715	-130.530	-192783.0769	31512.3138
.0077	1.3575	-149.135	-181961.5437	30955.2842
.0078	1.3417	-167.038	-176006.1552	30341.7473
.0079	1.3241	-184.317	-169482.4804	29658.9151
.0080	1.3049	-200.917	-162434.0123	28909.3248
.0081	1.2840	-216.788	-154906.8883	28095.7210
.0082	1.2615	-231.884	-146949.4729	27221.0381
.0083	1.2376	-246.165	-138611.9264	26288.3811
.0084	1.2123	-259.595	-129945.7643	25301.0062

MAXIMUM DEFLECTION	TIME
1.4138	0.0070

INPUT DATA FOR WINBLAST PROGRAM:
****
BLAST PRESSURE = 14.6 psi
BLAST DURATION = 26 msec
GLASS THICKNESS = .8080000000000001 in.
WINDOW SIZE = 40 x 40
ASPECT RATIO = 1
DAMPING PERCENTAGE = 4 %

TIME (sec)	DISPLACEMENT (in)	VELOCITY (in/sec)	ACCELERATION (in/sec2)	STRESS (psi)
.0001	0.0000	0.654	11885.7029	0.6533
.0002	0.0002	2.433	23668.6842	4.7679
.0003	0.0006	5.383	35300.2689	16.1462
.0004	0.0013	9.487	46735.7440	38.5501
.0005	0.0025	14.722	57931.3862	75.6798
.0006	0.0043	21.064	68844.6287	131.1593
.0007	0.0067	28.480	79434.2209	208.5228
.0008	0.0100	36.938	89660.3837	311.2013
.0009	0.0142	46.399	99484.9574	442.5098
.0010	0.0193	56.821	108871.5428	605.6345
.0011	0.0255	67.538	105418.8348	803.1355
.0012	0.0328	77.891	101571.2805	1034.7987
.0013	0.0411	87.840	97345.8935	1299.3948
.0014	0.0504	97.348	92761.0791	1595.5713
.0015	0.0605	106.381	87836.5558	1921.8588
.0016	0.0716	114.905	82593.2718	2276.6776
.0017	0.0835	122.889	77053.3163	2658.3446
.0018	0.0962	130.306	71239.8282	3065.0797
.0019	0.1096	137.129	65176.8998	3495.0142
.0020	0.1236	143.334	58889.4783	3946.1976
.0021	0.1382	148.900	52403.2638	4416.6064
.0022	0.1533	153.809	45744.6051	4904.1519
.0023	0.1689	158.044	38940.3934	5406.6889
.0024	0.1849	161.593	32017.9546	5922.0243
.0025	0.2012	164.445	25004.9402	6447.9258
.0026	0.2178	166.592	17929.2177	6982.1313
.0027	0.2345	168.030	10818.7603	7522.3571
.0028	0.2514	168.756	3701.5375	8066.3077
.0029	0.2683	168.771	-3394.5948	8611.6844
.0030	0.2851	168.078	-10442.0021	9156.1944
.0031	0.3018	166.685	-17413.3786	9697.5597
.0032	0.3184	164.599	-24281.8520	10233.5261
.0033	0.3347	161.833	-31021.0867	10761.8716
.0034	0.3508	158.400	-37605.3836	11280.4153
.0035	0.3664	154.298	-44642.0476	11794.1324
.0036	0.3816	149.499	-51307.2308	12308.0154
.0037	0.3963	144.044	-57751.9759	12804.8292
.0038	0.4104	137.957	-63946.6639	13282.3939
.0039	0.4239	131.264	-69862.5626	13738.6132
.0040	0.4366	123.995	-75472.0234	14171.4836
.0041	0.4486	116.181	-80748.6750	14579.1041
.0042	0.4598	107.807	-86599.2634	14960.6644
.0043	0.4702	98.912	-91236.1600	15313.9386
.0044	0.4796	89.574	-95458.8022	15636.4687
.0045	0.4881	79.835	-99246.1230	15926.8104
.0046	0.4956	69.740	-102579.3613	16183.6662
.0047	0.5020	59.335	-105442.2211	16405.8919
.0048	0.5074	48.668	-107821.0108	16592.5019

0.0049	0.5117	37.787	-109704.7605	16742.6740
0.0050	0.5150	26.744	-111085.3152	16855.7535
0.0051	0.5171	15.587	-111957.4031	16931.2557
0.0052	0.5181	4.369	-112318.6782	16968.8680
0.0053	0.5180	-6.859	-112169.7354	16968.4507
0.0054	0.5167	-18.048	-111514.0999	16930.0370
0.0055	0.5144	-29.145	-110358.1889	16853.8315
0.0056	0.5109	-40.103	-108711.2481	16740.2089
0.0057	0.5063	-50.871	-106585.2620	16589.7103
0.0058	0.5007	-61.404	-103994.8415	16403.0394
0.0059	0.4941	-71.655	-100957.0879	16181.0577
0.0060	0.4864	-81.581	-97491.4373	15924.7790
0.0061	0.4778	-91.140	-93619.4866	15635.3623
0.0062	0.4682	-100.292	-89364.8031	15314.1054
0.0063	0.4577	-109.001	-84752.7213	14962.4362
0.0064	0.4464	-117.195	-79020.7994	14582.7347
0.0065	0.4343	-124.843	-73897.5978	14177.1913
0.0066	0.4215	-131.966	-68505.2815	13746.5658
0.0067	0.4079	-138.536	-62872.0425	13292.6668
0.0068	0.3938	-144.533	-57026.7507	12817.3848
0.0069	0.3790	-149.936	-50998.7577	12322.6830
0.0070	0.3638	-154.728	-44817.7028	11810.5869
0.0071	0.3481	-158.874	-38330.2154	11297.4024
0.0072	0.3320	-162.408	-32330.8765	10779.4284
0.0073	0.3157	-165.337	-26235.1266	10250.8170
0.0074	0.2990	-167.653	-20067.2766	9713.5341

MAXIMUM DEFLECTION	TIME
0.5182	0.0052

APPENDIX D: This appendix presents a summary of the ABAQUS output. The output has been reduced to simply show a time verses deflection table.

The ABAQUS output included in this appendix is as shown on the following page.

WINDOW SIZE	THICKNESS	LOAD	PAGE NO.
26 x 26	0.71	14.6	D-3
36 x 36	0.71	14.6	D-4
40 x 40	0.71	14.6	D-5
72 x 72	1.06	14.6	D-6
72 x 72	1.06	30.0	D-7
72 x 72	1.06	40.0	D-8
72 x 72	1.06	50.0	D-9
27 x 20	0.71	14.6	D-10
32 x 20	0.71	14.6	D-11
72 x 24	0.71	14.6	D-12
72 x 24	0.71	75.0	D-13

Reduced ABAQUS Output

Blast Deflections of a 26" x 26" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01915
2.0	0.1091
2.8	0.1588
2.9	0.1599
3.0	0.1598
4.0	0.09545

Reduced ABAQUS Output

Blast Deflections of a 36" x 36" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01477
2.0	0.1391
3.0	0.3243
4.0	0.4903
4.2	0.5140
4.4	0.5307
4.6	0.5396
4.8	0.5417
5.0	0.5385
6.0	0.4617

Reduced ABAQUS Output

Blast Deflections of a 40" x 40" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01375
2.0	0.1327
3.0	0.3618
4.0	0.5702
5.0	0.7434
5.1	0.7532
5.2	0.7608
5.3	0.7662
5.4	0.7694
5.5	0.7706
5.6	0.7699
6.0	0.7532
7.0	0.6460

Reduced ABAQUS Output

Blast Deflections of a 72" x 72" heat-treated glass plate
Thickness = 1.06"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.00967
2.0	0.06167
3.0	0.2053
4.0	0.4719
5.0	0.8056
6.0	1.106
7.0	1.352
7.2	1.398
7.4	1.442
7.6	1.485
7.8	1.527
8.0	1.568
8.2	1.610
8.4	1.651
8.6	1.692
8.8	1.732
9.0	1.770
9.1	1.788
9.2	1.805
9.3	1.820
9.4	1.834
9.5	1.847
9.6	1.858
9.7	1.867
9.8	1.875
9.9	1.880
10.0	1.884
10.1	1.887
10.2	1.888
10.3	1.887
11.0	1.840
12.0	1.662

Reduced ABAQUS Output

Blast Deflections of a 72" x 72" heat-treated glass plate
Thickness = 1.06"
Load = 30.0 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01986
2.0	0.1267
3.0	0.4220
4.0	0.9689
5.0	1.630
6.0	2.141
7.0	2.485
7.2	2.546
7.4	2.604
7.6	2.662
7.8	2.718
8.0	2.774
8.2	2.829
8.4	2.881
8.6	2.929
8.8	2.967
9.0	2.993
9.1	3.000
9.2	3.003
9.3	3.001
10.0	2.861
11.0	2.416
12.0	1.900

Reduced ABAQUS Output

Blast Deflections of a 72" x 72" heat-treated glass plate
Thickness = 1.06"
Load = 40.0 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.02648
2.0	0.1690
3.0	0.5628
4.0	1.291
5.0	2.142
6.0	2.714
7.0	3.062
8.0	3.386
8.1	3.415
8.2	3.443
8.3	3.469
8.4	3.491
8.5	3.509
8.6	3.523
8.7	3.532
8.8	3.535
8.9	3.531
9.0	3.520
10.0	3.086

Reduced ABAQUS Output

Blast Deflections of a 72" x 72" heat-treated glass plate
Thickness = 1.06"
Load = 50.0 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.03310
2.0	0.2112
3.0	0.7037
4.0	1.509
5.0	2.628
6.0	3.212
7.0	3.558
8.0	3.746
9.0	3.920
9.1	3.946
9.2	3.967
9.3	3.982
9.4	3.990
9.5	3.991
9.6	3.984

Reduced ABAQUS Output

Blast Deflections of a 27" x 20" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01861
2.0	0.08382
2.1	0.08781
2.2	0.09067
2.3	0.09229
2.4	0.09266
2.5	0.09181
3.0	0.07082
4.0	0.03212

Reduced ABAQUS Output

Blast Deflections of a 32" x 20" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01805
2.0	0.09475
2.5	0.1138
2.6	0.1143
2.7	0.1138
3.0	0.1050
4.0	0.02545

Reduced ABAQUS Output

Blast Deflections of a 72" x 24" heat-treated glass plate
Thickness = 0.71"
Load = 14.6 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.01693
2.0	0.1086
3.0	0.2538
4.0	0.3687
5.0	0.3726
6.0	0.3747
7.0	0.3749
7.2	0.3733
7.4	0.3290
7.6	0.1646
7.8	-0.01163
8.0	-0.06248

Reduced ABAQUS Output

Blast Deflections of a 72" x 24" heat-treated glass plate
Thickness = 0.71"
Load = 75.0 psi

Time (Milliseconds)	Maximum Deflection (in.)
1.0	0.08696
2.0	0.5585
3.0	1.341
3.1	1.422
3.2	1.498
3.3	1.566
3.4	1.625
3.5	1.675
3.6	1.716
3.7	1.749
3.8	1.776

ABAQUS Model developed instabilities at this point due to excessive rotations in 18 of it's elements.

APPENDIX E: This appendix presents the master data base used by WINBLAST. The data consist of nondimensional summaries for equivalent mass, equivalent load, maximum deflections, and maximum stress for monolithic glass plates. In developing these values, Poisson's ratio was taken to be 0.21 and a modified version of the Vallabhan-Wang solution (5) was employed. The solution technique allows the nonlinear plate equations to be solved using a finite difference technique which takes approximately 600 divisions for the solutions. The following pages present results for 21 different aspect ratios ranging from 1.0 to 5.0 by increments of 0.2.

The first column of each table contains the nondimensional pressure, $\hat{q}$. The dimensionalized pressure, q, can be determined using the following equation:

$$q = \hat{q}Eh^2 / A^2 \qquad \text{(E1)}$$

where E is the modulus of elasticity, h is the plate thickness, and A is the area of the glass plate. The nondimensional pressures vary from 9.97 to 14,044.69. All response values corresponding to a pressures less than 9.97 are within the linear response regime so that linear interpolation can be used.

The second column of each table presents the natural logarithm of the nondimensional load, $\ln[\hat{q}]$. The natural logarithms of the nondimensional pressures vary form 2.3 to 9.55 by increments of 0.25.

The third and fourth columns in the tables present the equivalent mass and load respectively.

The fifth and the sixth columns present the nondimensional maximum lateral deflection, $\hat{\delta}$. and the nondimensional maximum stress, $\hat{\sigma}$, respectively. The dimensionalized deflection, Δ, can be determined as follows:

$$\Delta = \hat{\delta}h \tag{E2}$$

and the dimensionalized maximum stress, σ, can be determined as follows:

$$\sigma = \hat{\sigma}h^2 / A \tag{E3}$$

where all of the factors are as previously defined.

Nondimensional Plate Data for Aspect Ratio = 1.0

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2646	0.4212	0.45	2.74
12.81	2.55	0.2659	0.4226	0.56	3.48
16.44	2.80	0.2678	0.4246	0.70	4.36
21.12	3.05	0.2704	0.4274	0.86	5.40
27.11	3.30	0.2739	0.4311	1.04	6.57
34.81	3.55	0.2784	0.4358	1.25	7.87
44.70	3.80	0.2839	0.4416	1.48	9.36
57.40	4.05	0.2904	0.4483	1.73	11.11
73.70	4.30	0.2979	0.4560	2.01	13.17
94.63	4.55	0.3062	0.4645	2.31	16.07
121.51	4.80	0.3152	0.4735	2.65	19.92
156.02	5.05	0.3248	0.4831	3.01	24.72
200.34	5.30	0.3346	0.4928	3.41	30.75
257.24	5.55	0.3446	0.5026	3.86	38.31
330.30	5.80	0.3546	0.5123	4.35	47.82
424.11	6.05	0.3644	0.5218	4.90	59.74
544.57	6.30	0.3741	0.5310	5.50	74.67
699.24	6.55	0.3835	0.5399	6.16	93.34
897.85	6.80	0.3928	0.5485	6.89	117.15
1,152.86	7.05	0.4019	0.5570	7.70	147.92
1,480.30	7.30	0.4109	0.5652	8.58	186.77
1,900.74	7.55	0.4197	0.5732	9.55	235.59
2,440.60	7.80	0.4286	0.5812	10.61	296.47
3,133.79	8.05	0.4373	0.5890	11.77	371.64
4,023.87	8.30	0.4459	0.5967	13.04	463.13
5,166.75	8.55	0.4543	0.6041	14.43	573.26
6,634.24	8.80	0.4624	0.6113	15.94	733.82
8,518.54	9.05	0.4703	0.6184	17.60	926.45
10,938.02	9.30	0.4781	0.6254	19.41	1,148.60
14,044.69	9.55	0.4859	0.6323	21.38	1,470.70

Nondimensional Plate Data for Aspect Ratio = 1.2

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2653	0.4220	0.43	3.00
12.81	2.55	0.2665	0.4232	0.54	3.80
16.44	2.80	0.2682	0.4251	0.68	4.76
21.12	3.05	0.2707	0.4277	0.84	5.90
27.11	3.30	0.2741	0.4313	1.03	7.19
34.81	3.55	0.2784	0.4358	1.24	8.61
44.70	3.80	0.2837	0.4413	1.47	10.13
57.40	4.05	0.2900	0.4478	1.73	11.79
73.70	4.30	0.2971	0.4552	2.01	13.72
94.63	4.55	0.3050	0.4633	2.32	15.99
121.51	4.80	0.3135	0.4719	2.65	19.83
156.02	5.05	0.3224	0.4809	3.03	24.61
200.34	5.30	0.3316	0.4902	3.44	30.61
257.24	5.55	0.3410	0.4995	3.89	38.14
330.30	5.80	0.3503	0.5087	4.39	47.61
424.11	6.05	0.3597	0.5178	4.94	59.48
544.57	6.30	0.3689	0.5268	5.55	74.37
699.24	6.55	0.3781	0.5355	6.23	92.98
897.85	6.80	0.3872	0.5440	6.97	116.58
1,152.86	7.05	0.3961	0.5524	7.78	147.26
1,480.30	7.30	0.4051	0.5607	8.68	186.03
1,900.74	7.55	0.4141	0.5688	9.66	234.81
2,440.60	7.80	0.4231	0.5769	10.73	295.73
3,133.79	8.05	0.4320	0.5849	11.90	371.06
4,023.87	8.30	0.4408	0.5927	13.18	462.94
5,166.75	8.55	0.4493	0.6002	14.58	573.31
6,634.24	8.80	0.4576	0.6067	16.12	730.37
8,518.54	9.05	0.4659	0.6149	17.79	924.60
10,938.02	9.30	0.4739	0.6220	19.62	1,151.30
14,044.69	9.55	0.4816	0.6289	21.62	1,459.20

Nondimensional Plate Data for Aspect Ratio = 1.4

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2671	0.4239	0.40	3.12
12.81	2.55	0.2680	0.4249	0.51	3.96
16.44	2.80	0.2695	0.4265	0.64	4.99
21.12	3.05	0.2717	0.4287	0.80	6.23
27.11	3.30	0.2746	0.4318	0.98	7.65
34.81	3.55	0.2785	0.4359	1.19	9.25
44.70	3.80	0.2833	0.4409	1.43	10.99
57.40	4.05	0.2889	0.4467	1.70	12.84
73.70	4.30	0.2953	0.4534	1.99	14.78
94.63	4.55	0.3022	0.4606	2.31	16.97
121.51	4.80	0.3096	0.4683	2.67	19.57
156.02	5.05	0.3173	0.4763	3.05	24.31
200.34	5.30	0.3253	0.4845	3.48	30.24
257.24	5.55	0.3334	0.4928	3.95	37.68
330.30	5.80	0.3416	0.5011	4.47	47.01
424.11	6.05	0.3498	0.5095	5.04	58.73
544.57	6.30	0.3581	0.5177	5.67	73.41
699.24	6.55	0.3665	0.5260	6.37	91.78
897.85	6.80	0.3751	0.5342	7.14	115.09
1,152.86	7.05	0.3837	0.5424	7.98	145.39
1,480.30	7.30	0.3925	0.5505	8.90	183.71
1,900.74	7.55	0.4015	0.5588	9.90	231.89
2,440.60	7.80	0.4106	0.5670	11.00	292.06
3,133.79	8.05	0.4197	0.5751	12.20	366.43
4,023.87	8.30	0.4288	0.5832	13.51	457.08
5,166.75	8.55	0.4377	0.5911	14.95	566.21
6,634.24	8.80	0.4465	0.5988	16.52	721.93
8,518.54	9.05	0.4553	0.6065	18.23	913.51
10,938.02	9.30	0.4637	0.6138	20.10	1,136.90
14,044.69	9.55	0.4719	0.6210	22.15	1,444.40

Nondimensional Plate Data for Aspect Ratio = 1.6

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2697	0.4267	0.36	3.14
12.81	2.55	0.2705	0.4275	0.46	4.00
16.44	2.80	0.2717	0.4287	0.59	5.07
21.12	3.05	0.2734	0.4305	0.74	6.37
27.11	3.30	0.2758	0.4330	0.92	7.92
34.81	3.55	0.2789	0.4363	1.13	9.70
44.70	3.80	0.2830	0.4406	1.37	11.71
57.40	4.05	0.2878	0.4456	1.65	13.89
73.70	4.30	0.2932	0.4513	1.95	16.22
94.63	4.55	0.2990	0.4575	2.29	18.68
121.51	4.80	0.3052	0.4641	2.66	21.29
156.02	5.05	0.3117	0.4710	3.07	24.35
200.34	5.30	0.3184	0.4781	3.52	29.66
257.24	5.55	0.3252	0.4854	4.01	36.98
330.30	5.80	0.3321	0.4927	4.56	46.16
424.11	6.05	0.3392	0.5002	5.15	57.70
544.57	6.30	0.3465	0.5077	5.81	72.17
699.24	6.55	0.3540	0.5153	6.54	90.28
897.85	6.80	0.3617	0.5230	7.34	113.05
1,152.86	7.05	0.3698	0.5307	8.21	142.91
1,480.30	7.30	0.3781	0.5387	9.17	180.72
1,900.74	7.55	0.3867	0.5467	10.21	228.35
2,440.60	7.80	0.3955	0.5548	11.35	287.97
3,133.79	8.05	0.4045	0.5629	12.60	361.89
4,023.87	8.30	0.4136	0.5711	13.96	452.37
5,166.75	8.55	0.4228	0.5792	15.44	561.33
6,634.24	8.80	0.4322	0.5874	17.06	711.66
8,518.54	9.05	0.4413	0.5954	18.82	903.53
10,938.02	9.30	0.4502	0.6031	20.75	1,127.90
14,044.69	9.55	0.4590	0.6107	22.86	1,420.90

Nondimensional Plate Data for Aspect Ratio = 1.8

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2734	0.4305	0.32	3.09
12.81	2.55	0.2739	0.4310	0.41	3.95
16.44	2.80	0.2746	0.4319	0.53	5.02
21.12	3.05	0.2759	0.4331	0.67	6.36
27.11	3.30	0.2776	0.4350	0.84	7.99
34.81	3.55	0.2801	0.4376	1.05	9.92
44.70	3.80	0.2833	0.4409	1.29	12.16
57.40	4.05	0.2871	0.4450	1.57	14.68
73.70	4.30	0.2915	0.4497	1.88	17.46
94.63	4.55	0.2963	0.4548	2.24	20.47
121.51	4.80	0.3014	0.4604	2.63	23.66
156.02	5.05	0.3067	0.4663	3.06	27.03
200.34	5.30	0.3122	0.4723	3.53	30.72
257.24	5.55	0.3179	0.4786	4.05	36.05
330.30	5.80	0.3238	0.4851	4.62	45.07
424.11	6.05	0.3299	0.4917	5.25	56.38
544.57	6.30	0.3363	0.4986	5.94	70.60
699.24	6.55	0.3429	0.5055	6.70	88.42
897.85	6.80	0.3498	0.5126	7.53	110.70
1,152.86	7.05	0.3571	0.5198	8.44	140.04
1,480.30	7.30	0.3647	0.5273	9.44	177.28
1,900.74	7.55	0.3726	0.5348	10.53	224.28
2,440.60	7.80	0.3808	0.5425	11.73	283.21
3,133.79	8.05	0.3893	0.5504	13.02	356.41
4,023.87	8.30	0.3981	0.5584	14.44	446.22
5,166.75	8.55	0.4072	0.5665	15.98	554.65
6,634.24	8.80	0.4166	0.5748	17.66	700.14
8,518.54	9.05	0.4260	0.5830	19.49	890.87
10,938.02	9.30	0.4353	0.5911	21.48	1,115.40
14,044.69	9.55	0.4446	0.5991	23.66	1,395.60

Nondimensional Plate Data for Aspect Ratio = 2.0

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2777	0.4350	0.29	2.99
12.81	2.55	0.2779	0.4353	0.37	3.83
16.44	2.80	0.2786	0.4359	0.47	4.89
21.12	3.05	0.2793	0.4367	0.60	6.23
27.11	3.30	0.2805	0.4380	0.76	7.89
34.81	3.55	0.2822	0.4397	0.95	9.91
44.70	3.80	0.2844	0.4421	1.19	12.32
57.40	4.05	0.2873	0.4452	1.46	15.13
73.70	4.30	0.2907	0.4489	1.79	18.32
94.63	4.55	0.2944	0.4530	2.15	21.87
121.51	4.80	0.2984	0.4576	2.56	25.75
156.02	5.05	0.3028	0.4625	3.01	29.90
200.34	5.30	0.3073	0.4676	3.51	34.30
257.24	5.55	0.3121	0.4731	4.06	38.94
330.30	5.80	0.3171	0.4788	4.66	44.25
424.11	6.05	0.3224	0.4847	5.32	54.84
544.57	6.30	0.3280	0.4908	6.04	68.77
699.24	6.55	0.3339	0.4972	6.83	86.26
897.85	6.80	0.3401	0.5370	7.70	108.16
1,152.86	7.05	0.3465	0.5104	8.66	136.72
1,480.30	7.30	0.3533	0.5172	9.70	173.32
1,900.74	7.55	0.3605	0.5243	10.84	219.60
2,440.60	7.80	0.3679	0.5314	12.09	277.74
3,133.79	8.05	0.3757	0.5388	13.44	350.09
4,023.87	8.30	0.3839	0.5464	14.92	439.05
5,166.75	8.55	0.3926	0.5543	16.53	546.74
6,634.24	8.80	0.4016	0.5623	18.28	687.78
8,518.54	9.05	0.4108	0.5705	20.18	876.84
10,938.02	9.3	0.4202	0.5787	22.26	1,100.50
14,044.69	9.55	0.4298	0.5870	24.52	1,370.20

Nondimensional Plate Data for Aspect Ratio = 2.2

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2826	0.4400	0.25	2.87
12.81	2.55	0.2828	0.4030	0.32	3.69
16.44	2.80	0.2831	0.4406	0.41	4.72
21.12	3.05	0.2836	0.4411	0.53	6.03
27.11	3.30	0.2842	0.4418	0.67	7.67
34.81	3.55	0.2853	0.4429	0.86	9.71
44.70	3.80	0.2867	0.4445	1.08	12.21
57.40	4.05	0.2886	0.4465	1.35	15.22
73.70	4.30	0.2909	0.4492	1.66	18.73
94.63	4.55	0.2936	0.4522	2.03	22.76
121.51	4.80	0.2967	0.4558	2.45	27.28
156.02	5.05	0.3001	0.4598	2.93	32.22
200.34	5.30	0.3038	0.4641	3.45	37.53
257.24	5.55	0.3077	0.4687	4.02	43.22
330.30	5.80	0.3120	0.4737	4.65	49.15
424.11	6.05	0.3166	0.4790	5.34	55.53
544.57	6.30	0.3215	0.4845	6.10	66.68
699.24	6.55	0.3267	0.4903	6.93	83.80
897.85	6.80	0.3322	0.4963	7.84	105.26
1,152.86	7.05	0.3380	0.5024	8.83	133.00
1,480.30	7.30	0.3440	0.5087	9.92	168.91
1,900.74	7.55	0.3504	0.5152	11.11	214.39
2,440.60	7.80	0.3571	0.5218	12.42	271.60
3,133.79	8.05	0.3641	0.5286	13.83	342.90
4,023.87	8.30	0.3716	0.5358	15.38	430.86
5,166.75	8.55	0.3796	0.5432	17.06	537.61
6,634.24	8.80	0.3880	0.5508	18.89	674.37
8,518.54	9.05	0.3967	0.5587	20.88	861.50
10,938.02	9.30	0.4058	0.5667	23.04	1,083.10
14,044.69	9.55	0.4153	0.5750	25.38	1,344.50

Nondimensional Plate Data for Aspect Ratio = 2.4

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2881	0.4570	0.22	2.75
12.81	2.55	0.2883	0.4459	0.29	3.52
16.44	2.80	0.2884	0.4460	0.37	4.51
21.12	3.05	0.2886	0.4462	0.47	5.78
27.11	3.30	0.2889	0.4466	0.60	7.38
34.81	3.55	0.2894	0.4471	0.76	9.40
44.70	3.80	0.2900	0.4479	0.97	11.92
57.40	4.05	0.2910	0.4490	1.22	15.01
73.70	4.30	0.2924	0.4506	1.53	18.73
94.63	4.55	0.2941	0.4527	1.89	23.13
121.51	4.80	0.2962	0.4552	2.32	28.18
156.02	5.05	0.2986	0.4582	2.80	33.85
200.34	5.30	0.3015	0.4617	3.34	40.07
257.24	5.55	0.3047	0.4656	3.94	46.77
330.30	5.80	0.3082	0.4698	4.61	53.94
424.11	6.05	0.3122	0.4745	5.33	61.41
544.57	6.30	0.3165	0.4794	6.12	69.22
699.24	6.55	0.3210	0.4847	6.99	81.05
897.85	6.80	0.3259	0.4901	7.94	102.01
1,152.86	7.05	0.3311	0.4958	8.97	129.06
1,480.30	7.30	0.3365	0.5150	10.11	164.22
1,900.74	7.55	0.3422	0.5075	11.35	208.81
2,440.60	7.80	0.3482	0.5136	12.71	264.97
3,133.79	8.05	0.3545	0.5199	14.19	335.06
4,023.87	8.30	0.3613	0.5265	15.80	421.50
5,166.75	8.55	0.3685	0.5334	17.55	526.39
6,634.24	8.80	0.3762	0.5405	19.46	661.73
8,518.54	9.05	0.3842	0.5479	21.54	845.59
10,938.02	9.30	0.3928	0.5557	23.79	1,062.60
14,044.69	9.55	0.4019	0.5637	26.24	1,323.70

Nondimensional Plate Data for Aspect Ratio = 2.6

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.2942	0.4170	0.20	2.61
12.81	2.55	0.2941	0.4517	0.25	3.35
16.44	2.80	0.2942	0.4518	0.32	4.30
21.12	3.05	0.2942	0.4518	0.42	5.51
27.11	3.30	0.2942	0.4519	0.53	7.06
34.81	3.55	0.2943	0.4520	0.68	9.02
44.70	3.80	0.2944	0.4523	0.87	11.49
57.40	4.05	0.2947	0.4527	1.10	14.59
73.70	4.30	0.2951	0.4534	1.39	18.41
94.63	4.55	0.2958	0.4544	1.74	23.02
121.51	4.80	0.2968	0.4558	2.16	28.47
156.02	5.05	0.2983	0.4579	2.65	34.76
200.34	5.30	0.3003	0.4604	3.20	41.81
257.24	5.55	0.3027	0.4635	3.82	49.55
330.30	5.80	0.3056	0.4670	4.51	57.88
424.11	6.05	0.3088	0.4710	5.27	66.77
544.57	6.30	0.3125	0.4753	6.09	76.06
699.24	6.55	0.3165	0.4800	7.00	85.71
897.85	6.80	0.3209	0.4850	7.99	98.38
1,152.86	7.05	0.3255	0.4901	9.07	124.89
1,480.30	7.30	0.3303	0.4955	10.25	159.23
1,900.74	7.55	0.3355	0.5100	11.55	202.84
2,440.60	7.80	0.3408	0.5066	12.96	257.81
3,133.79	8.05	0.3466	0.5125	14.50	326.41
4,023.87	8.30	0.3526	0.5186	16.18	410.82
5,166.75	8.55	0.3591	0.5249	18.00	512.95
6,634.24	8.80	0.3660	0.5315	19.99	649.19
8,518.54	9.05	0.3734	0.5384	22.15	828.50
10,938.02	9.30	0.3814	0.5457	24.50	1,038.80
14,044.69	9.55	0.3898	0.5533	27.05	1,306.70

Nondimensional Plate Data for Aspect Ratio = 2.8

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3003	0.4578	0.17	2.48
12.81	2.55	0.3004	0.4579	0.22	3.19
16.44	2.80	0.3002	0.4577	0.29	4.09
21.12	3.05	0.3003	0.4578	0.37	5.25
27.11	3.30	0.3001	0.4577	0.47	6.72
34.81	3.55	0.2999	0.4576	0.60	8.61
44.70	3.80	0.2997	0.4575	0.77	11.01
57.40	4.05	0.2993	0.4573	0.99	14.05
73.70	4.30	0.2990	0.4573	1.26	17.85
94.63	4.55	0.2987	0.4573	1.59	22.56
121.51	4.80	0.2988	0.4578	1.99	28.25
156.02	5.05	0.2993	0.4587	2.47	34.98
200.34	5.30	0.3002	0.4603	3.03	42.74
257.24	5.55	0.3018	0.4624	3.66	51.43
330.30	5.80	0.3039	0.4652	4.37	60.96
424.11	6.05	0.3065	0.4678	5.16	71.23
544.57	6.30	0.3095	0.4722	6.02	82.15
699.24	6.55	0.3130	0.4763	6.97	93.60
897.85	6.80	0.3168	0.4808	8.00	105.50
1,152.86	7.05	0.3209	0.4855	9.13	120.84
1,480.30	7.30	0.3253	0.4904	10.36	154.09
1,900.74	7.55	0.3299	0.4955	11.70	197.03
2,440.60	7.80	0.3349	0.5008	13.17	251.49
3,133.79	8.05	0.3400	0.5063	14.77	319.92
4,023.87	8.30	0.3455	0.5119	16.52	404.80
5,166.75	8.55	0.3513	0.5177	18.42	508.42
6,634.24	8.80	0.3576	0.5238	20.49	634.12
8,518.54	9.05	0.3643	0.5302	22.75	815.86
10,938.02	9.30	0.3715	0.5370	25.19	1,032.50
14,044.69	9.55	0.3793	0.5441	27.85	1,281.10

Nondimensional Plate Data for Aspect Ratio = 3.0

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3067	0.4640	0.15	2.36
12.81	2.55	0.3066	0.4640	0.20	3.03
16.44	2.80	0.3066	0.4640	0.26	3.89
21.12	3.05	0.3066	0.4639	0.33	4.99
27.11	3.30	0.3063	0.4637	0.42	6.40
34.81	3.55	0.3059	0.4634	0.54	8.20
44.70	3.80	0.3055	0.4631	0.69	10.51
57.40	4.05	0.3048	0.4626	0.88	13.45
73.70	4.30	0.0390	0.4620	1.13	17.18
94.63	4.55	0.3029	0.4614	1.44	21.85
121.51	4.80	0.3020	0.4608	1.82	27.64
156.02	5.05	0.3014	0.4608	2.28	34.63
200.34	5.30	0.3014	0.4612	2.83	42.89
257.24	5.55	0.3020	0.4624	3.47	52.38
330.30	5.80	0.3032	0.4642	4.19	63.00
424.11	6.05	0.3051	0.4667	5.00	74.61
544.57	6.30	0.3074	0.4698	5.90	87.10
699.24	6.55	0.3103	0.4733	6.88	100.44
897.85	6.80	0.3136	0.4773	7.96	114.39
1,152.86	7.05	0.3172	0.4816	9.13	128.89
1,480.30	7.30	0.3212	0.4861	10.41	148.53
1,900.74	7.55	0.3254	0.4909	11.81	190.39
2,440.60	7.80	0.3299	0.4958	13.33	243.52
3,133.79	8.05	0.3346	0.5008	14.99	310.31
4,023.87	8.30	0.3395	0.5060	16.81	393.15
5,166.75	8.55	0.3448	0.5114	18.78	494.07
6,634.24	8.80	0.3505	0.5171	20.93	620.99
8,518.54	9.05	0.3566	0.5230	23.27	798.29
10,938.02	9.30	0.3631	0.5293	25.81	1,008.10
14,044.69	9.55	0.3702	0.5359	28.57	1,255.30

Nondimensional Plate Data for Aspect Ratio = 3.2

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3131	0.4702	0.14	2.24
12.81	2.55	0.3133	0.4703	0.18	2.88
16.44	2.80	0.3131	0.4702	0.23	3.69
21.12	3.05	0.3129	0.4701	0.29	4.74
27.11	3.30	0.3127	0.4699	0.38	6.08
34.81	3.55	0.3123	0.4696	0.48	7.81
44.70	3.80	0.3117	0.4692	0.62	10.01
57.40	4.05	0.3108	0.4685	0.79	12.84
73.70	4.30	0.3096	0.4675	1.02	16.44
94.63	4.55	0.3089	0.4663	1.30	21.01
121.51	4.80	0.3063	0.4651	1.65	26.75
156.02	5.05	0.3048	0.4640	2.09	33.86
200.34	5.30	0.3036	0.4634	2.62	42.42
257.24	5.55	0.3032	0.4635	3.25	52.51
330.30	5.80	0.3034	0.4643	3.98	64.07
424.11	6.05	0.3044	0.4660	4.81	76.96
544.57	6.30	0.3061	0.4683	5.73	91.04
699.24	6.55	0.3084	0.4712	6.75	106.15
897.85	6.80	0.3111	0.4746	7.87	122.29
1,152.86	7.05	0.3143	0.4784	9.09	139.13
1,480.30	7.30	0.3178	0.4826	1.04	156.59
1,900.74	7.55	0.3216	0.4869	1.19	183.76
2,440.60	7.80	0.3257	0.4915	1.35	236.10
3,133.79	8.05	0.3300	0.4962	1.52	302.37
4,023.87	8.30	0.3345	0.5011	1.71	385.25
5,166.75	8.55	0.3394	0.5062	1.91	487.18
6,634.24	8.80	0.3445	0.5114	2.13	610.04
8,518.54	9.05	0.3500	0.5169	2.38	782.65
10,938.02	9.30	0.3560	0.5227	2.64	997.69
14,044.69	9.55	0.3624	0.5289	2.93	1,246.10

Nondimensional Plate Data for Aspect Ratio = 3.4

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3198	0.4765	0.12	2.13
12.81	2.55	0.3197	0.4765	0.16	2.74
16.44	2.80	0.3197	0.4764	0.20	3.51
21.12	3.05	0.3196	0.4764	0.26	4.51
27.11	3.30	0.3192	0.4760	0.34	5.79
34.81	3.55	0.3188	0.4757	0.43	7.43
44.70	3.80	0.3182	0.4752	0.56	9.54
57.40	4.05	0.3173	0.4745	0.71	12.24
73.70	4.30	0.3158	0.4733	0.91	15.70
94.63	4.55	0.3139	0.4718	1.17	20.12
121.51	4.80	0.3117	0.4701	1.50	25.74
156.02	5.05	0.3093	0.4682	1.91	32.79
200.34	5.30	0.3071	0.4666	2.41	41.49
257.24	5.55	0.3055	0.4656	3.02	51.94
330.30	5.80	0.3047	0.4654	3.75	64.21
424.11	6.05	0.3047	0.4660	4.58	78.20
544.57	6.30	0.3056	0.4674	5.52	93.75
699.24	6.55	0.3071	0.4696	6.57	110.68
897.85	6.80	0.3093	0.4725	7.72	128.83
1,152.86	7.05	0.3119	0.4758	8.99	148.10
1,480.30	7.30	0.3150	0.4795	10.38	168.21
1,900.74	7.55	0.3184	0.4835	11.88	189.04
2,440.60	7.80	0.3222	0.4877	13.52	227.65
3,133.79	8.05	0.3261	0.4922	15.30	292.06
4,023.87	8.30	0.3303	0.4967	17.24	372.51
5,166.75	8.55	0.3347	0.5014	19.36	471.17
6,634.24	8.80	0.3394	0.5063	21.67	591.38
8,518.54	9.05	0.3444	0.5114	24.18	764.91
10,938.02	9.30	0.3498	0.5168	26.91	971.57
14,044.69	9.55	0.3557	0.5226	29.87	1,208.00

Nondimensional Plate Data for Aspect Ratio = 3.6

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3263	0.4826	0.11	2.03
12.81	2.55	0.3263	0.4827	0.14	2.60
16.44	2.80	0.3261	0.4825	0.18	3.34
21.12	3.05	0.3260	0.4824	0.24	4.29
27.11	3.30	0.3258	0.4823	0.30	5.51
34.81	3.55	0.3254	0.4819	0.39	7.07
44.70	3.80	0.3247	0.4818	0.50	9.08
57.40	4.05	0.3238	0.4806	0.64	11.66
73.70	4.30	0.3224	0.4795	0.82	14.97
94.63	4.55	0.3203	0.4779	1.06	19.22
121.51	4.80	0.3177	0.4758	1.36	24.65
156.02	5.05	0.3147	0.4734	1.73	31.54
200.34	5.30	0.3116	0.4709	2.21	40.19
257.24	5.55	0.3089	0.4688	2.79	50.81
330.30	5.80	0.3069	0.4675	3.50	63.55
424.11	6.05	0.3059	0.4670	4.32	78.41
544.57	6.30	0.3058	0.4675	5.28	95.28
699.24	6.55	0.3066	0.4689	6.35	113.95
897.85	6.80	0.3081	0.4710	7.53	134.19
1,152.86	7.05	0.3102	0.4738	8.84	155.82
1,480.30	7.30	0.3128	0.4770	10.28	178.81
1,900.74	7.55	0.3158	0.4807	11.84	202.72
2,440.60	7.80	0.3192	0.4846	13.54	227.44
3,133.79	8.05	0.3228	0.4887	15.38	283.03
4,023.87	8.30	0.3267	0.4930	17.39	363.13
5,166.75	8.55	0.3308	0.4975	19.58	462.40
6,634.24	8.80	0.3351	0.5020	21.97	582.74
8,518.54	9.05	0.3397	0.5068	24.56	747.10
10,938.02	9.30	0.3446	0.5118	27.38	958.19
14,044.69	9.55	0.3500	0.5172	30.45	1,203.10

Nondimensional Plate Data for Aspect Ratio = 3.8

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3325	0.4884	0.10	1.93
12.81	2.55	0.3324	0.4884	0.13	2.48
16.44	2.80	0.3326	0.4885	0.17	3.19
21.12	3.05	0.3324	0.4884	0.21	4.09
27.11	3.30	0.3322	0.4882	0.27	5.25
34.81	3.55	0.3317	0.4878	0.35	6.74
44.70	3.80	0.3312	0.4874	0.45	8.66
57.40	4.05	0.3304	0.4868	0.58	11.12
73.70	4.30	0.3290	0.4856	0.75	14.29
94.63	4.55	0.3270	0.4841	0.96	18.35
121.51	4.80	0.3243	0.4819	1.23	23.58
156.02	5.05	0.3209	0.4791	1.58	30.26
200.34	5.30	0.3171	0.4761	2.02	38.73
257.24	5.55	0.3134	0.4731	2.57	49.34
330.30	5.80	0.3102	0.4706	3.25	62.29
424.11	6.05	0.3080	0.4690	4.06	77.75
544.57	6.30	0.3068	0.4684	5.01	95.68
699.24	6.55	0.3067	0.4689	6.09	115.88
897.85	6.80	0.3075	0.4702	7.30	138.13
1,152.86	7.05	0.3090	0.4724	8.65	162.15
1,480.30	7.30	0.3111	0.4751	10.13	187.76
1,900.74	7.55	0.3137	0.4783	11.75	214.98
2,440.60	7.80	0.3167	0.4819	13.51	243.15
3,133.79	8.05	0.3200	0.4857	15.42	273.72
4,023.87	8.30	0.3236	0.4898	17.50	353.01
5,166.75	8.55	0.3274	0.4940	19.76	452.02
6,634.24	8.80	0.3314	0.4983	22.22	573.07
8,518.54	9.05	0.3356	0.5028	24.90	728.21
10,938.02	9.30	0.3402	0.5075	27.81	941.41
14,044.69	9.55	0.3451	0.5152	30.99	1,191.90

Nondimensional Plate Data for Aspect Ratio = 4.0

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3390	0.4943	0.09	1.84
12.81	2.55	0.3385	0.4939	0.12	2.37
16.44	2.80	0.3387	0.4941	0.15	3.04
21.12	3.05	0.3386	0.4940	0.19	3.91
27.11	3.30	0.3384	0.4938	0.25	5.01
34.81	3.55	0.3381	0.4936	0.32	6.44
44.70	3.80	0.3375	0.4932	0.41	8.27
57.40	4.05	0.3367	0.4925	0.53	10.62
73.70	4.30	0.3356	0.4916	0.68	13.64
94.63	4.55	0.3337	0.4901	0.87	17.53
121.51	4.80	0.3310	0.4880	1.12	22.53
156.02	5.05	0.3275	0.4851	1.44	28.96
200.34	5.30	0.3233	0.4817	1.84	37.19
257.24	5.55	0.3188	0.4780	2.36	47.61
330.30	5.80	0.3146	0.4745	3.00	60.59
424.11	6.05	0.3111	0.4718	3.78	76.35
544.57	6.30	0.3088	0.4700	4.71	95.03
699.24	6.55	0.3076	0.4695	5.80	116.52
897.85	6.80	0.3075	0.4700	7.03	140.59
1,152.86	7.05	0.3083	0.4717	8.41	166.95
1,480.30	7.30	0.3099	0.4736	9.92	195.33
1,900.74	7.55	0.3120	0.4763	11.60	225.62
2,440.60	7.80	0.3146	0.4795	13.41	257.30
3,133.79	8.05	0.3176	0.4830	15.39	290.20
4,023.87	8.30	0.3209	0.4868	17.53	339.27
5,166.75	8.55	0.3244	0.4907	19.86	434.95
6,634.24	8.80	0.3281	0.4648	22.40	551.60
8,518.54	9.05	0.3320	0.4990	25.16	709.91
10,938.02	9.30	0.3363	0.5034	28.16	915.02
14,044.69	9.55	0.3408	0.5081	31.43	1,153.20

Nondimensional Plate Data for Aspect Ratio = 4.2

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3447	0.4996	0.08	1.76
12.81	2.55	0.3447	0.4995	0.11	2.26
16.44	2.80	0.3446	0.4995	0.14	2.91
21.12	3.05	0.3444	0.4993	0.18	3.73
27.11	3.30	0.3443	0.4993	0.23	4.79
34.81	3.55	0.3441	0.4991	0.29	6.15
44.70	3.80	0.3436	0.4987	0.37	7.90
57.40	4.05	0.3430	0.4983	0.48	10.15
73.70	4.30	0.3420	0.4974	0.62	13.04
94.63	4.55	0.3403	0.4961	0.79	16.76
121.51	4.80	0.3378	0.4941	1.02	21.55
156.02	5.05	0.3344	0.4914	1.31	27.72
200.34	5.30	0.3300	0.4878	1.68	35.65
257.24	5.55	0.3250	0.4837	2.16	45.79
330.30	5.80	0.3199	0.4794	2.76	58.59
424.11	6.05	0.3152	0.4756	3.51	74.46
544.57	6.30	0.3116	0.4727	4.42	93.59
699.24	6.55	0.3093	0.4710	5.49	116.07
897.85	6.80	0.3082	0.4705	6.73	141.73
1,152.86	7.05	0.3082	0.4711	8.13	170.29
1,480.30	7.30	0.3091	0.4726	9.68	201.39
1,900.74	7.55	0.3108	0.4748	11.39	234.71
2,440.60	7.80	0.3130	0.4776	13.27	270.12
3,133.79	8.05	0.3156	0.4808	15.31	307.06
4,023.87	8.30	0.3186	0.4843	17.53	345.30
5,166.75	8.55	0.3218	0.4880	19.94	423.50
6,634.24	8.80	0.3253	0.4919	22.55	540.55
8,518.54	9.05	0.3290	0.4959	25.40	689.82
10,938.02	9.30	0.3329	0.5000	28.49	896.68
14,044.69	9.55	0.3371	0.5044	31.85	1,139.90

Nondimensional Plate Data for Aspect Ratio = 4.4

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3509	0.5051	0.08	1.69
12.81	2.55	0.3505	0.5048	0.10	2.17
16.44	2.80	0.3504	0.5048	0.13	2.78
21.12	3.05	0.3503	0.5047	0.16	3.57
27.11	3.30	0.3503	0.5047	0.21	4.59
34.81	3.55	0.3500	0.5044	0.27	5.89
44.70	3.80	0.3497	0.5042	0.34	7.56
57.40	4.05	0.3491	0.5038	0.44	9.71
73.70	4.30	0.3482	0.5030	0.56	12.48
94.63	4.55	0.3468	0.5019	0.72	16.04
121.51	4.80	0.3446	0.5002	0.93	20.62
156.02	5.05	0.3414	0.4976	1.20	26.53
200.34	5.30	0.3371	0.4942	1.54	34.15
257.24	5.55	0.3318	0.4899	1.98	43.95
330.30	5.80	0.3260	0.4850	2.54	56.45
424.11	6.05	0.3203	0.4803	3.25	72.18
544.57	6.30	0.3154	0.4762	4.12	91.51
699.24	6.55	0.3119	0.4733	5.17	114.67
897.85	6.80	0.3097	0.4717	6.40	141.63
1,152.86	7.05	0.3087	0.4714	7.81	172.14
1,480.30	7.30	0.3089	0.4722	9.40	205.82
1,900.74	7.55	0.3100	0.4738	11.15	242.28
2,440.60	7.80	0.3117	0.4761	13.08	281.17
3,133.79	8.05	0.3140	0.4790	15.19	322.50
4,023.87	8.30	0.3166	0.4821	17.48	365.34
5,166.75	8.55	0.3196	0.4856	19.96	411.14
6,634.24	8.80	0.3228	0.4892	22.66	528.62
8,518.54	9.05	0.3263	0.4930	25.59	671.06
10,938.02	9.30	0.3299	0.4970	28.78	875.50
14,044.69	9.55	0.3338	0.5011	32.24	1,124.30

Nondimensional Plate Data for Aspect Ratio = 4.6

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3565	0.5102	0.07	1.62
12.81	2.55	0.3559	0.5098	0.09	2.08
16.44	2.80	0.3557	0.5096	0.11	2.66
21.12	3.05	0.3557	0.5096	0.15	3.42
27.11	3.30	0.3559	0.5097	0.19	4.39
34.81	3.55	0.3554	0.5094	0.24	5.64
44.70	3.80	0.3554	0.5093	0.31	7.24
57.40	4.05	0.3549	0.5089	0.40	9.31
73.70	4.30	0.3540	0.5083	0.52	11.95
94.63	4.55	0.3528	0.5073	0.66	15.36
121.51	4.80	0.3509	0.5058	0.85	19.75
156.02	5.05	0.3481	0.5036	1.10	25.40
200.34	5.30	0.3441	0.5004	1.41	32.71
257.24	5.55	0.3389	0.4961	1.82	42.13
330.30	5.80	0.3327	0.4911	2.34	54.24
424.11	6.05	0.3262	0.4857	3.00	69.65
544.57	6.30	0.3202	0.4806	3.83	88.91
699.24	6.55	0.3153	0.4765	4.84	112.39
897.85	6.80	0.3118	0.4737	6.05	140.26
1,152.86	7.05	0.3099	0.4724	7.46	172.38
1,480.30	7.30	0.3092	0.4723	9.06	208.39
1,900.74	7.55	0.3096	0.4732	10.85	247.87
2,440.60	7.80	0.3108	0.4750	12.82	290.41
3,133.79	8.05	0.3127	0.4774	14.99	335.86
4,023.87	8.30	0.3150	0.4803	17.35	383.37
5,166.75	8.55	0.3177	0.4835	19.91	432.70
6,634.24	8.80	0.3207	0.4869	22.68	514.42
8,518.54	9.05	0.3239	0.4905	25.70	657.46
10,938.02	9.30	0.3273	0.4943	28.97	851.35
14,044.69	9.55	0.3310	0.4982	32.53	1,103.20

Nondimensional Plate Data for Aspect Ratio = 4.8

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3610	0.5143	0.06	1.55
12.81	2.55	0.3616	0.5147	0.08	1.99
16.44	2.80	0.3610	0.5143	0.11	2.56
21.12	3.05	0.3609	0.5143	0.14	3.28
27.11	3.30	0.3609	0.5143	0.17	4.22
34.81	3.55	0.3609	0.5142	0.22	5.41
44.70	3.80	0.3607	0.5141	0.29	6.95
57.40	4.05	0.3603	0.5138	0.37	8.93
73.70	4.30	0.3596	0.5132	0.47	11.47
94.63	4.55	0.3586	0.5125	0.61	14.74
121.51	4.80	0.3570	0.5112	0.78	18.94
156.02	5.05	0.3546	0.5092	1.01	24.37
200.34	5.30	0.3510	0.5064	1.30	31.37
257.24	5.55	0.3460	0.5024	1.67	40.41
330.30	5.80	0.3398	0.4973	2.15	52.09
424.11	6.05	0.3327	0.4915	2.77	67.08
544.57	6.30	0.3257	0.4857	3.55	86.06
699.24	6.55	0.3195	0.4804	4.52	109.61
897.85	6.80	0.3148	0.4765	5.70	138.02
1,152.86	7.05	0.3117	0.4740	7.09	171.39
1,480.30	7.30	0.3100	0.4729	8.70	209.45
1,900.74	7.55	0.3097	0.4731	10.51	251.77
2,440.60	7.80	0.3103	0.4743	12.53	297.87
3,133.79	8.05	0.3117	0.4763	14.74	347.26
4,023.87	8.30	0.3136	0.4787	17.18	399.65
5,166.75	8.55	0.3160	0.4817	19.81	454.27
6,634.24	8.80	0.3188	0.4849	22.67	510.75
8,518.54	9.05	0.3218	0.4883	25.77	643.32
10,938.02	9.30	0.3250	0.4918	29.14	824.92
14,044.69	9.55	0.3284	0.4956	32.79	1,079.70

Nondimensional Plate Data for Aspect Ratio = 5.0

Nondimensional Lateral Pressure $\hat{q}$	Natural Logarithm of Nondimensional Lateral Pressure $\ln[\hat{q}]$	Mass Equivalency Factor K_M	Load Equivalency Factor K_L	Nondimensional Maximum Deflection $\hat{\delta}$	Nondimensional Maximum Stress $\hat{\sigma}$
9.97	2.30	0.3668	0.5194	0.06	1.49
12.81	2.55	0.3662	0.5189	0.08	1.92
16.44	2.80	0.3664	0.5191	0.10	2.46
21.12	3.05	0.3661	0.5189	0.13	3.16
27.11	3.30	0.3663	0.5190	0.16	4.05
34.81	3.55	0.3661	0.5189	0.21	5.20
44.70	3.80	0.3656	0.5185	0.27	6.68
57.40	4.05	0.3654	0.5184	0.34	8.58
73.70	4.30	0.3649	0.5180	0.44	11.02
94.63	4.55	0.3641	0.5173	0.56	14.16
121.51	4.80	0.3628	0.5163	0.72	18.20
156.02	5.05	0.3607	0.5146	0.93	23.40
200.34	5.30	0.3575	0.5121	1.20	30.12
257.24	5.55	0.3530	0.5085	1.54	38.80
330.30	5.80	0.3469	0.5036	1.99	50.03
424.11	6.05	0.3397	0.4977	2.56	64.52
544.57	6.30	0.3320	0.4913	3.29	83.07
699.24	6.55	0.3247	0.4851	4.22	106.40
897.85	6.80	0.3186	0.4800	5.35	135.04
1,152.86	7.05	0.3142	0.4763	6.72	169.29
1,480.30	7.30	0.3115	0.4742	8.32	209.03
1,900.74	7.55	0.3102	0.4735	10.14	253.90
2,440.60	7.80	0.3102	0.4740	12.19	303.35
3,133.79	8.05	0.3110	0.4754	14.46	356.80
4,023.87	8.30	0.3126	0.4775	16.94	413.72
5,166.75	8.55	0.3147	0.4801	19.66	473.97
6,634.24	8.80	0.3171	0.4830	22.60	536.40
8,518.54	9.05	0.3199	0.4862	25.79	627.07
10,938.02	9.30	0.3229	0.4896	29.25	801.10
14,044.69	9.55	0.3262	0.4932	33.01	1,053.50

References

(1) "Structures to Resist the Effects of Accidental Explosions," Departments of the Army, the Navy, and the Air Force (TM 5-1300, NAVFAC P-397, AFM 88-22), June 1969.

(2) ABAQUS Users' Manual, Version 4-9 (1990) Hibbitt, Karlsson, and Sorensen, Inc., Providence, R. I.

(3) Watt, J. M., Tilson, D. L., (1992), "Airblast Testing of Blast-Resistant Window Systems," Technical Report SL-92-8, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, MS.

(4) Beason, W.L., and Morgan, J.R., "Glass Failure Prediction Model," Journal of Structural Engineering, ASCE, Vol. 110, No. 2, February, 1984, pp. 197-212.

(5) Vallabhan, C.V.G. and Wang, B. Y-T., "Nonlinear Analysis of Rectangular Plates by Finite Difference Method," Institute for Disaster Research, Texas Tech University, Lubbock, Texas, 1981.

(6) Paz, M., (1985), "Structural Dynamics: Theory and Computation - Third Edition," Van Nostrand Reinhold, New York.

(7) Biggs, J. M., (1964) "Introduction to Structural Dynamics," Mcgraw-Hill Book Company, New York.

(8) "Design of Structures to resist the Effects of Atomic Weapons - Structural Elements Subjected to Dynamic Loads," Manual - Corps of Engineers, U.S. Army, EM 1110-345-416, March 1957.

(9) PATRAN Plus User Manual, Release 2.5, (1990) PDA Engineering, Costa Mesa, CA.

(10) Behr, R.A., Minor, J.E., Norville, H.S., "Structural Behavior of Architectural Laminated Glass," Journal of Structural Engineering, ASCE, Vol. 119, No. 1, January, 1993, pp. 202-222.

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